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Forthcoming Events.

MARCH 13.

Institute of Metals (Swansea Local Section):—General discussion at Swansea.

West of Scotland Iron and Steel Institute:—Ordinary meeting at Glasgow. "Fuel in the Iron and Steel Industry." Paper by E. C. Evans.

Junior Institution of Engineers:—Ordinary meeting in London. "Notes on Methods of Producing Modern High-grade Machine Tools." Paper by A. P. Bale.

MARCH 14.

Institute of British Foundrymen (Wales and Monmouthshire):—Ordinary meeting at Newport. "Loose Tackle for Jobbing and Repetition Foundries." Paper by H. Longden.

Institute of British Foundrymen:—Ordinary meeting at Glasgow. "Oil Sand and Binders." Paper by J. McEachan.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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A Commercially-Voiceless Industry.

It is conceivable that certain sections of the foundry industry would be benefited by their inclusion in the list of trades to be covered by the Safeguarding of Industries arrangements. Assuming this to be the case, it is as well to bear in mind the recent negative decision given in the case of the Midlands glass trade, the ruling being based upon the fact that as an industry it was too small. Now the foundry trade of Great Britain, whilst being one of its largest industries, is an adjunct of every sphere of manufacturing activity and is almost completely disconnected. It is linked up for technical study by means of two national associations. Its conduct, so far as wages are concerned, is governed by a dozen employers' federations and half-a-dozen trade unions. So far as questions, which affect the industry nationally, are concerned, it has no means of expressing itself. When trade is partially good the section of the industry which is most prosperous is in a position to pay prices for labour and raw materials which are prohibitive to the remainder. If a section doing badly requires help from the Safeguarding of Industries Act, it will be too small. The foundry industry is suffering very badly from its lack of organisation. It is not cognisant of the extent of its foreign competition, and no body exists to place before the Board of Trade the need for a better classification.

The larger firms are apparently still relying on quality to keep their heads above water. Recently the buyer of a very large electrical concern told us that his firm had had to scrap some very large turbo casings bought from the Continent. But the foundry has had the experience of British requirements and cannot be relied upon to fail every time. Again, a prominent manufacturer of steel castings insisted to us that his firm were regaining business from the Continent because of the enhanced quality of the British material. This is what we would expect so far as the home markets are concerned, because the British buyer has a craving after quality inherently within him. But what of the foreign market? Generally speaking, castings bought from the Continent would probably be better than what can be made in the overseas markets.

Quality, whilst an excellent weapon in meeting competition, is only of a transient value. A foundry having had a few years of experience in the meeting of any market condition can usually adapt itself to the necessary requirements. *Experientia docet*, and it is hinted in the daily Press that some of our foreign competitors are willing to pay a high price to obtain a thoroughly good experience of the British home and overseas markets. The methods of dealing with this situation unfortunately form the basis of a political controversy, but whatever the personal political feelings of foundry owners may be, it is obvious that it is desirable that they should have a means of expressing themselves, as foundrymen, with a national voice.

During the last ten days much has been heard of the loss of shipbuilding orders to Holland and Germany, and even the daily Press has hinted that it is very largely the price of castings which has influenced the business. If marine castings get any aid from the Safeguarding of Industries Act it will be due to the efforts of shipbuilders as shipbuilders and not as foundry owners. Castings too quickly lose their identity after manufacture, and only become important as another entity—a lathe bed or a steam cylinder.

XUM

The Refractories Association.

ANNUAL DINNER.

The sixth annual dinner of the Refractories Association was held at the Royal Victoria Hotel, Sheffield, last Friday, and was attended by about 70 gentlemen. Mr. F. J. Boam, of Leicester and King's Lynn (the newly-elected President), occupied the chair, and, before the speechmaking commenced, he was the central figure in a pleasing little ceremony. Mr. Frank Russell, the retiring President, has presented to the Association a chain of office as a memento of his year, and he formally invested Mr. Boam with this emblem, at the same time speaking in terms of high appreciation of Mr. Boam's services as one of the founders of the Association. The chain is of silver gilt, and contains a number of medallions, on which the names of successive Presidents will be inscribed.

Professor W. E. S. Turner, in proposing "The Refractories Association," also paid a tribute to the work of Mr. Boam, and spoke especially of the high value of his sand in glass making. The Association was formed with the express object of developing all that was best in connection with the refractories industry: the quarrying and getting of the various minerals used, and the investigation of the best uses to which they could be put. Dr. Mellor suggested that the glass and steel manufacturers would be constantly crying out for another 20 deg., and another 50 deg., and so on. But progress was being made, and he believed that some of the very best goods that had been made out of that new and very promising material, silliminite, had been produced by members of their Association. They were doing very fine work in connection with it.

Mr. Boam, in reply, said the Association was in no way formed to control selling prices of any of their products, but to take up matters of interest to those engaged in the production of refractory and allied materials, so that they could know that their goods were the best of their kind, and were being produced by the most up-to-date methods. They achieved this largely through having for Secretary an experienced chemist like Mr. W. J. Rees, who was also of great help to them in interviewing railway companies and Government Departments, as he had had an all-round training.

Mr. Job Holland proposed "Our Guests." He said there was no doubt that the modern tendency was, and would be, for refractories to be asked to do bigger service than ever they had done in the past. The time had arrived when it was essential that the best service should be obtained from any class of work, and it was up to the members of the Refractories Association to trim their sails and to put themselves in order to meet the requirements that would arise and were arising daily. Those requirements would be infinitely greater than anything that was known 20 years ago. That Association, fortunately, was not a trade association in any way, but was for the diffusion of knowledge. Their principal guest that evening was Mr. Herbert Wragg, M.P., who was President of the Clay Workers' Institute, and upon whom a greater honour would shortly be conferred, for he was to be the first President of the first Clay Convention to be held in this country. That convention would be held at Buxton in May, and would be visited by ten or twelve Associations.

Mr. Herbert Wragg, M.P., who was received with musical honours, spoke of the value of science in conducing to the prosperity of business. Business success ought to be a source of gratification to the Labour Party, because a business that was a success could at any rate afford to pay its working people a better wage than one which was not a success. The refractory industry of this country, or any other industry, could only continue to prosper by having peace, by trying to bring together the different interests representing capital, labour and management.

Mr. G. H. M. Turner, in a humorous speech, proposed "Kindred Associations and Interests."

Colonel S. C. Halse, C.M.G. (Society of Glass Technology), said they in the glass trade must regard the members of the Refractories Association as comrades in arms, in helping them to deal with the biggest trouble that they had—the life of their tanks and the continual running of their plant, which was of such enormous importance to them.

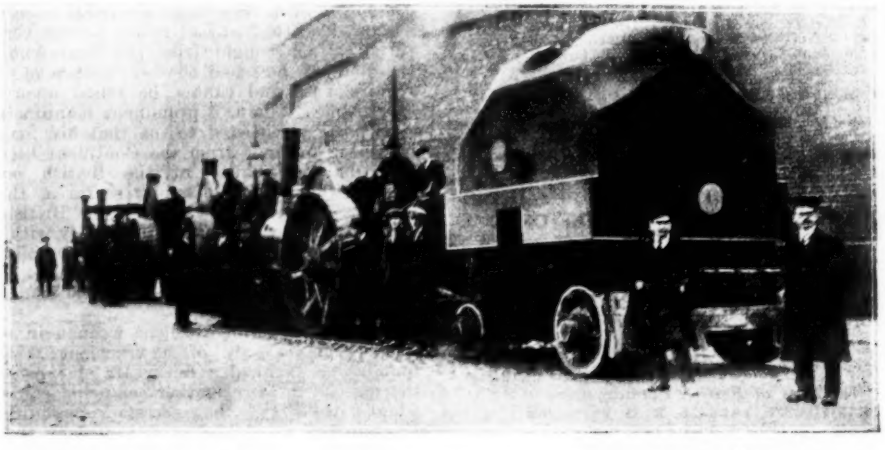
Mr. W. E. Salisbury (London, Midland and Scottish Railway), who further responded, said railway charges were dear to the hearts of business men, because they were always hoping for some reduction.

"The Retiring Officers" were toasted on the call of Mr. W. J. Gardner, and Mr. F. Russell responded.

A 95-ton Casting.

An anvil block weighing 95 tons was recently made by the Brightside Foundry and Engineering Company, Limited, Sheffield. The pattern was constructed in their Wicker Works pattern shop, which is well equipped on modern lines for dealing with all kinds of jobbing work.

The mould was built up with bricks and composition loam, and several building rings were used in the course of construction. The pattern withdrawn, the mould was sleeked, blacked and finished and thoroughly dried, and then the cores were placed in position. When the top was located and secured, the space between the outside of the mould and the sides of the pit was rammed up, and care was taken to ensure that the lateral pressure was resisted. There were two runners entering at the bottom, one at each side of the mould, and another one from the stand ladle was cut in about a third of the way up.



The question of the metal proved very interesting. To obtain the necessary quantity, four cupolas and two air furnaces were blowing simultaneously. The cupolas provided roughly 28 tons of metal per hour, and the metal was all down in three hours. The cast began at 10 a.m., and the metal was through the riser in 4½ minutes. A stand ladle of 42 tons capacity was used, together with one 23-ton ladle and two 17-ton ladles. The feeding of this huge casting took approximately 30 hours, and it was left in the pit for about a fortnight, to be lifted out finally by means of a 120-ton crane.

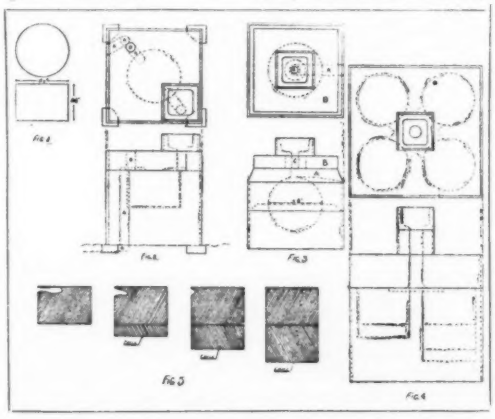
The company have in the past cast heavier castings for local works. It is, we understand, the heaviest load in one piece ever carried by rail.

Some Considerations on Liquid Shrinkage in Grey Iron.*

By John Longden, A.M.I.Brit.F.

The questions arising out of the phenomenon of liquid shrinkage in cupola melted grey iron are of first importance to foundrymen. Only those in the industry have any comprehension of the extreme difficulty of producing a casting, of complicated design, which shall be sound in every particular. A great deal of this difficulty is directly due to the tendency of cast iron to shrink in volume, whilst passing from the liquid to the solid state. With the difficulties which may arise, consequent on the contraction in volume which continues after solidification is complete, the writer is not presently concerned.

This subject has been investigated by several eminent metallurgists, but it cannot be said that they have yet reached quite definite conclusions upon it. Mallet,[1] in 1874, was of the opinion that cast iron did not expand on solidification. After a number of experiments, he concluded that the alleged fact of expansion on freezing was illusory. In 1882, Roberts-Austen and Wrightson,[2] using the "tektometer," carried out a series of experiments, and concluded that cast iron, in passing from the solid to the liquid, increased in volume by 1.02 per cent. Hatfield,[3] however, is of opinion "that their work cannot be considered quite conclusive." In 1906, Professor Turner,



using the "extensometer," proved that grey irons do expand on solidification. Other writers have demonstrated, arithmetically, that liquid iron is heavier, per unit of volume, than is iron which has just solidified; in other words, that grey iron expands on passing from the liquid to the solid. C. Benedicks, D. W. Berlin and G. Phragmen[4] have recently developed an apparatus for the determination of specific gravities of metals of high melting points; and, in respect of a soft iron, have reached results which are said to confirm those obtained by Roberts-Austen and Wrightson. Finally, Smalley,[5] who has carried out an extensive series of experiments in this connection, concludes that "cupola-melted grey cast iron, of normal chemical composition, does not shrink on solidification, if poured with a sufficient degree of superheat, and if cooled faster than a certain critical rate."

Experimental Data.

Does grey iron shrink on solidification? If so, by how much, and in what circumstances? To find an answer to these questions the writer carried out the following experiments. The methods adopted were of a practical character, though it is to be feared they would not be commended by the careful laboratory worker. Further, the writer regrets that he had not available at the time a suitable pyrometer. Nevertheless, the writer is convinced that the broad results prove the conclusions reached.

If the liquid shrinkage of a given volume of metal is to be ascertained by any method which is capable of use in the foundry, it is necessary to eliminate head metal which always feeds the casting below it in some degree. If iron be cast into an open mould, it is difficult to measure its volume, even approximately, before solidification. To overcome this difficulty a cylindrical solid body, as shown in Fig. 1, was moulded in green sand, as shown in Fig. 2. As will be seen from the sketch as soon as the mould was full the excess metal at once drained away through the channel A. The hole through the top part at B was placed there to ensure that there should be no possibility of metal syphoning out of the mould, which was therefore left just full of metal, the mould having been made truly level. This was poured with metal having silicon 2.52 per cent. and total carbon 3.84 per cent. Out of the same shank of metal another mould (which had been made in the ordinary way with a 2-in. dia. riser in the centre of the top of the mould) was cast and fed up solid with a rod. The two castings, when cool, were carefully cleaned, whilst the riser of the one was ground away exactly level with the face of the casting. The external dimensions of the two

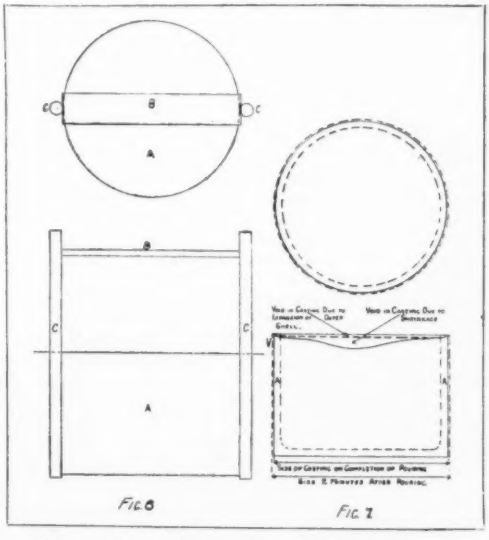


FIG. 6 FIG. 7

castings, as ascertained by calipers, were equal, except in depth, the one cast without head having sunk fairly evenly, as shown in Fig. 11. There is no room for doubt that the volume of the metal in this mould, whilst wholly liquid, was equal to that in the one which was fed, excluding, of course, metal in the runner and riser of the fed casting. The irregularities of the sunken surface of the former prevented anything but a rough estimation by measurement of the volume change.

Volume Difference as Shown by Weight.

A simpler method presented itself which could be depended upon to give relatively greater accuracy, *i.e.*, weighing, which would also take account of internal draws. The weight of the solidly fed casting was found to be 23 lbs. 10 ozs., whilst that of the shrunken casting was 22 lbs. 9 ozs. Taking equal weights of metal of the same composition as representing equal volumes, the difference in volume is 4.49 per cent.

This experiment was repeated with hot metal having silicon 2.42 per cent. and total carbon 3.92 per cent., with very similar results. The fed casting weighed 23 lbs. 11 ozs., whilst the casting without head weighed 22 lbs. 9¼ ozs., the difference in volume thus registered being 4.62 per cent. The pipe in the run-off casting is indicated at Fig. 12. In every case in these and the succeeding experiments the sand used was of an open character, with a moisture content of from 6 to 7 per cent., rammed tightly, but not too hard,

D

* A Paper read before the Falkirk Section of the Institute of British Foundrymen, Mr. Primrose presiding.

and well vented. There can be no question of blow holes in the casting.

With regard to these experiments, it may be said there is no assurance, in the circumstances, that the run-off moulds were really full of metal. In reply it may be pointed out that, when the castings were taken out the top sharp outer edge was to be seen all round (see No. 2, Fig. 20), proving that the metal had filled all the space. In each case in casting some 10 lbs. of metal were run through the mould. It may further be objected that the author's method of measuring liquid shrinkage is unsatisfactory, in that it is sought to measure it by the weighing of two castings at normal temperature. It seems clear, however, that once the stage of complete solidification has been passed, the two castings follow each other down the cooling curve, the conditions being fairly constant in each case. The slight difference in mass might be expected to promote some little difference in the condition of the carbon, but such difference is negligible. As a check upon the relative accuracy of this method, two moulds were made in the same way—one to run off level and one to be fed up solid. These were cast with commercially pure (98 per cent.) aluminium at 700 deg. C. When cleaned up, the fed casting weighed 8 lbs. 1 oz. and the run-off casting 7 lbs. 9 ozs., showing a difference of 6.2 per cent. Mr. Hikozô Endo[6] has ascertained the liquid shrinkage of several of the lower melting point metals by means of the "thermobalance." In the case of aluminium, he ascertained the volume reduction during solidification as a mean of three estimations to be 6.26 per cent.

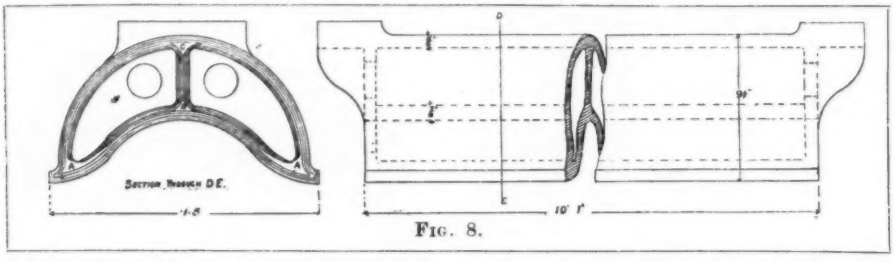


Fig. 8.

Experiments with Spherical Castings.

With a view to ascertaining whether a differently shaped casting would give a different result, a sphere $5\frac{3}{4}$ in. dia. was moulded in dry sand, as shown in Fig. 3. As will be seen in the sketch, the mould was designed with a flow-off at A, level with the top of the sphere, so that the mould would fill just full and no more. The mould was well dried and cast with hot metal having silicon 2.36 and total carbon 3.92 per cent. The casting was found to have sunk flatly at the top to a depth of $\frac{5}{8}$ in., as indicated at Fig. 13. Its weight was 24 lbs. $2\frac{1}{4}$ ozs. Another drysand mould from the same pattern was cast from the same shank of metal, but this was fed solid through a riser on the top. The weight of this casting, when cleaned up, was found to be 24 lbs. 12 ozs. The volume ratio of these castings (as measured by weight) differed markedly from the blocks cast in green sand, the run-off casting being only 2.41 per cent. less in volume than the fed casting. The reason for this difference is important, and will be dealt with later. Four moulds of the cylindrical block were again made in green sand, three to be run-off level and one having a large riser for feeding. The four moulds were poured out of one shank of a denser metal having silicon 1.55 and total carbon 3.41 per cent. in the following way. The metal was caught at the furnace spout, and the first mould made to run off level was cast. The mould made to be fed up solid was then cast and the shank laid down. After a lapse of $2\frac{1}{2}$ minutes from the time when the first was cast the second mould made to run-off level was cast. After a further $2\frac{1}{2}$ minutes the metal in the shank was becoming distinctly dull, and the third run-off mould was cast. When the fed casting was weighed it was found to be 24lbs. 3 ozs., whilst the three run-off castings, in the order of casting, weighed 23 lbs. 2 ozs., 23 lbs. 1 oz. and 23 lbs. 2 ozs. respectively. The pipes in the tops of these castings are shown in Figs. 17, 18 and 19 respectively. A photograph of the two halves of the casting indicated at Fig. 17 is shown at No. 2, Fig. 20. The differences in volume, as against the solid casting, were 4.39, 4.65 and 4.39 per cent. respectively. It is of moment to note that there is no very marked difference among the three castings as regards tendency to shrink, in spite of the fact that they were cast at widely different temperatures. Another mould, made in the same way, was cast in a metal having silicon 1.45 and total carbon 2.85 per cent. This metal was crucible melted and cast rather dull. The casting weighed 23 lbs. 1 oz. and piped at the top, as shown in Fig. 16.

Rapidly Cooled Castings.

With a view to ascertaining whether a quickly cooled casting would show any difference from the preceding results, the following steps were first taken to find the depth of chill which, given sufficient head of metal, would give freedom from shrinkage cavities.

Four moulds of the cylindrical block were made in one moulding box, with heavy cut runners connected with a heavy central down gate, as shown in Fig. 4. Below one casting was put no chill; under the second was put a chill having one-third the depth of the mould; under the third a chill two-thirds the depth of the mould; and, under the fourth, a chill equal to the depth of the mould.

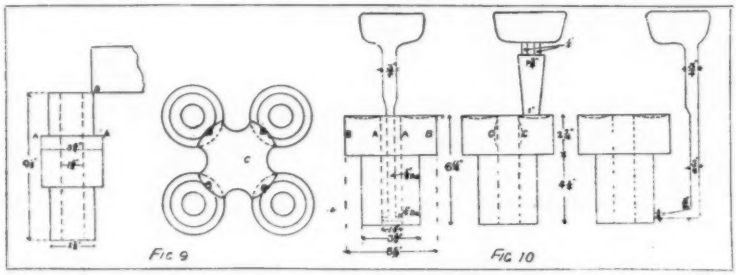


Fig 9 Fig 10

When the castings were taken out, the casting with full depth chill was found to be quite solid, the sawn section being shown at No. 3, Fig. 20. The other castings were found to have drawn as shown in Fig. 5.

Thus having found the weight of chill necessary to ensure soundness, if cast in the ordinary way, but with large runners, and a good head of metal, a mould was then made as shown in Fig. 2, with the full depth chill placed below it, and provision being made for all metal to flow off which was not necessary to fill the mould properly. The mould was cast with hot metal having silicon 1.92, and total carbon 3.80 per cent. About 10 lbs. of metal was run through the flow-off. When stripped, the casting was found to have sunk heavily, as shown at Fig. 14; its weight being 22 lbs. $6\frac{1}{2}$ ozs. To try out this again, two moulds were made in the same box. A chill as deep as the pattern was placed underneath each. A separate down-gate was placed

to each, but arranged so as to come into the same runner basin; one having provision for 8-in. head of metal, with 1¼-in. down runner and a 3 in. by ½ in. cut runner at the joint. The other was made to drain away all metal above the level of the joint. The result was a solid casting in the first case, whilst the second was sunk to an average depth of $\frac{3}{16}$ in. The metal used was of a similar composition to the last.

Influence of Slow Pouring.

A further experiment was carried out in connection with slow running. A mould was made as in Fig. 2, except that the metal entered the mould through a ¼-in. diameter runner, near the bottom of the casting; the mould to fill only to the joint. The mould was cast with hot metal having silicon 2.19 and T.C. 3.65 per cent. Some 12 lbs. of metal were run through the flow-off. The casting, when stripped, showed a sunken top as shown at Fig. 15, and weighed 22 lbs. 6 ozs. No fed castings were weighed against this and the chilled

22 lbs. 9 ozs. 22 lbs. 9½ ozs. 24 lbs. 2½ ozs.

Weight of fed casting, 23 lbs. 10 ozs. C.C., 0.21; G.C., 3.63; Si., 2.52.

Weight of fed casting, 23 lbs. 11 ozs. C.C., 0.22; G.C., 3.70; Si., 2.46.

C.C., 0.29; G.C., 3.63; Si., 2.36.

FIG. 11. FIG. 12. FIG. 13.

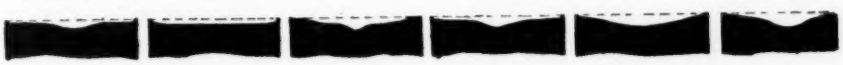
casting, but it is notable that both are lighter than those in the first experiments, though the metal used was denser.

In respect of all the above experiments, the only analyses taken were of silicon and total carbon. In previous determinations of similar mixtures, however, the other elements have been found to range within the following limits: Phosphorus. 0.60 to 0.70; manganese, 0.42 to 0.60; and sulphur, 0.08 to 0.11 per cent.

Effect of Liquid Shrinkage.

In regard to the results obtained above, is it certain that the whole of the difference in volume, as between the fed castings and the others, is attributable to liquid shrinkage? Professor Turner[7] has shown that grey iron expands immediately after solidification. This is shown to be due to the breaking down of iron carbide into the bulkier condition of free iron and graphite. In all probability no carbon is freed (in an iron not supersaturated) before the main solidification is

22 lbs. 6½ ozs. 22 lbs. 6 ozs. 23 lbs. 1 oz. 23 lbs. 2 ozs. 23 lbs. 1 oz. 23 lbs. 2 ozs.



Heavy chill beneath casting. C.C., 0.35; G.C., 3.45; Si., 1.92.

Pencil Runner. C.C., 0.26; G.C., 3.34; Si., 2.19.

C.C., 0.40; G.C., 2.45; Si., 1.46.

Weight of fed casting: 24 lbs. 3 ozs.

C.C., 0.33; G.C., 3.08; Si., 1.55.

FIG. 14. FIG. 15. FIG. 16. FIG. 17. FIG. 18. FIG. 19.

complete (locally) before which primary crystallisation is complete. As it is in crystallisation that the change of volume is most seriously effected, the mischief is then already done. Granting, however, that the separation of graphite expands the metal, how far can it be shown to neutralise the already accomplished shrinkage? At this stage may be considered the "box effect" favoured by the late Mr. Buchanan,[8] and, to some extent, endorsed by Professor Turner.[9] If a cube be cast, a thin film of solidified metal at once forms on the walls of the mould. As the metal cools, this film grows thicker, building up from the walls inwards. Assuming insufficient resistance from the mould, the solidified walls will expand, each in the direction of its length, as well as in other directions; so that the cube is, whilst solidification is proceeding, actually bigger than the original mould, and thus, unless new metal enters, a cavity is accounted for. To try out this idea, within the limits of the means of the writer, a mould of the cylindrical block was made, in green sand, as shown in Fig. 2. In addition, two steel rods, ⅜-in. dia., were rammed up at two opposite sides of the pattern, as shown at C, Fig. 6. The rods stood up through the top part of the mould, holes 1 in. in diameter being left for that purpose, the holes being covered at the joint by pieces of tin which had been drilled for the rods to pass through. Above the top of the box a bar, B, was placed, the length of which was exactly the distance between the rods CC. The mould was cast with hot metal having silicon 1.59 and total carbon 3.65 per cent. Two minutes after casting it was ascertained, by means of feelers inserted between the rods CC and the bar B, that the casting shell had expanded 0.034 in., and at the end of 2½ minutes from the time of casting the expansion had increased to 0.054 in. No further expansion was discernible.

At the moment when the block had expanded across its diameter 0.054 in., the circumference would correspondingly be increased by 0.17 in. The cubical contents of the block would thereby be increased by 1.817 cub. in. If, as seems very probable, the linear expansion of the sides took place in a vertical direction also at the same rate, the increase in depth of the casting would be 0.038 in., making a further increase in the capacity of the block of 0.92 cub. in. The total increase of volume at the moment when the maximum expansion was reached would be, therefore, 2.737 cub. in., or 0.714 lbs. If this result be subtracted from the difference between the casting referred to in Fig. 17 (which was cast in a metal of similar composition) and the fed casting, there is left a residual shrinkage percentage of 1.44 per cent., which would remain if the whole of the expansion had been directed inwards to the heart of the casting.

This was tried out again, but with a drysand mould of the cylindrical block. Hot metal having silicon 2.45 and total carbon 3.90 per cent. was poured into it; and an expansion of 0.021 in. was registered at the end of 3 minutes, after which no further expansion took place. If this expansion and a vertical expansion of the same linear ratio be taken as in the last case, it would increase the capacity of the block, at the moment of maximum expansion, by 0.707 cub. in. or 0.163 lb. Following this, two moulds were made in drysand from the same pattern, one to run-off level with the top of the mould, as in Fig. 2, the other to be fed solid. Metal having silicon 2.51 and total carbon 3.89 per cent. was poured, hot, into them. When cleaned and weighed, the fed casting weighed 23 lbs. 1 oz., whilst the run-off casting weighed 22 lbs. 8½ ozs.—a difference of 2.3 per cent., which agrees very well with that reached in connection with the spheres cast in drysand.

If from this difference be taken the value of the increased volume of the castings at the moment of maximum expansion—in terms of weight, 2.29 ozs.—the difference is reduced to 1.595 per cent. The latter is net shrinkage which would remain if the whole of the expansion had been directed inwards. An attempt to show pictorially the factors which go to produce the pipes in the run-off castings is shown at Fig. 7. Shell expansion would cause an immediate void, which would be followed by a further void due to the progressive failure of the expansion to compensate fully for the loss of volume due to liquid shrinkage.

Origin of Pipes.

In further consideration of this part of the question, it may be said that, if cast iron did not shrink in volume on leaving the liquid state, the outer shell would solidify first and duly expand. Successive layers of the metal would solidify and expand in turn until the whole was solid. If the expansion of each layer took place in the same ratio as the preceding one, the result must be a solid casting without any shrinkage cavities; but

one which, soon after casting, had become temporarily larger than the mould. In Figs. 21 to 27 are shown microphotographs taken from the areas blacked out at A, B and C, No. 2 of Fig. 20. Figs. 21, 22 and 23 respectively show, from the side to the centre, the relative disposition of primary graphite. Whilst the centre section shows less primary graphite than the outside section, and more secondary graphite, there is evidence that the post-solidification expansion had continued, though perhaps at a slightly diminishing rate, right to the centre of the casting. In spite of this, however, a large pipe is finally left in the casting. It would appear, therefore, that each layer of metal cooled and expanded, but such expansion was progressively insufficient to make

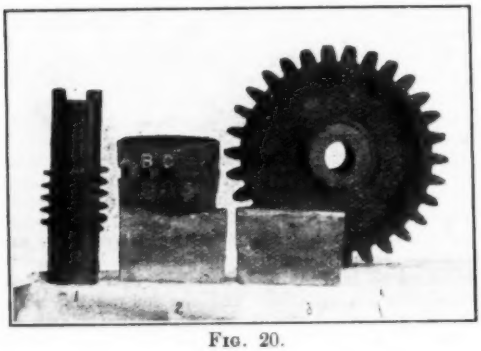


Fig. 20.

up the loss of volume by shrinkage on crystallisation. It seems very likely that the pipes in the green-sand-cast blocks really represent the degree of shrinkage on crystallisation. A green-sand mould offers so little resistance to the post-solidification expansion that each shell would expand to its limit. This would be just as true of the solidly fed castings as of the ones which were run-off level with the top of the mould. It may further be said, without extravagance, that the ratio of expansion per unit of volume would be closely alike in both castings. In the case of the fed casting, the initial void due to shell expansion would at once be made good by metal fed down the riser. The progressive shrinking would also be made up. Consequently, the fed casting simply represents what the unfed casting would be but

Fig. 21.—Unetched × 75 dias.—Edge.*

for liquid shrinkage. The true liquid shrinkage (preceding expansion) of these grey irons, therefore, is fairly represented by the differences between their respective weights, which differences are shown above to be from 4.39 to 4.65 per cent. Figs. 24 and 25, and Figs. 25 and 26, taken from areas A and C respectively (Fig. 20, No. 2), show that the irons used are quite of a normal character. A point of interest is the shrinkage cavity shown in the top right-hand corner of Fig. 23. The number of these cavities to be found in the centre of the casting indicate that the whole of the shrinkage is not in the pipe.

* All the micros have been reduced 50 per cent. in reproduction.

In all sand-made castings, therefore, the voids left are the combined resultants of two factors—shell expansion and net liquid shrinkage. In the green-sand moulds dealt with above, if the castings are to come out solid, round about 4.5 per cent. of new metal must be put into it whilst solidification is proceeding; and, in the drysand mould, round about 2.35 per cent. This result does not appear to be appreciably affected by temperature of metal at pouring, rate of cooling, speed of pouring, or composition—within the limits drawn by the above experiments.

How Expansion Factor Operates.

From what has been said, it is clearly brought out that grey iron of the composition dealt with, when cast into a mould, can only result in a sound casting if a sufficient supply of new metal is got into it whilst solidification is proceeding. Whilst, owing to the differently shaped sections of many castings, the expansion factor may work often wholly in the direction of aiding solidity, in other cases the factor may work to the detriment of solidity; but, in every case, not less than 1.5 per cent. of new metal must pass into the mould, whilst solidification is going on. This is equally true of parts of a mould which are chilled. The true function of a chill is therefore implicit in that name. The word "densener" may have a more pleasing sound, but the fact is that the function of a chill is so to hasten the solidification of the part concerned that new metal can flow to that part whilst a liquid channel of metal is open to it; otherwise the chill is ineffective, or it is effective in the degree in which that function has been carried out. This must also be true of the all-metal mould. The solidity obtained thereby is the resultant (1) of post-solidification expansion being directed inwards, and (2) of the fact that

Fig. 22.—Unetched × 75 dias.—Next to Edge.

the casting cools rapidly, the net shrinkage being made up just as rapidly from the runner.

Shrinkage Factor Often Masked.

In workshop practice, however, the shrinkage factor is often hidden; indeed, it is in many ways compensated for, otherwise the production of sound castings of an important character in this metal would be very difficult. Nevertheless, it leaves its witness, as an examination of any old castings which have been broken up will show. When cast iron is poured into a mould, the metal flows from the basin down the runner gate, filling first the bottom portions of the mould, then gradually filling up to the top and passing through the risers. The metal which comes through a riser is always much cooler than that remaining in the runner head. Hence a riser seldom naturally feeds a casting. The runner, however, is always the hottest part of the casting, and serves to feed the solidifying casting for so long as any part of its (the runner's) cross section remains liquid to the casting proper. Further, in any casting the region near the runner remains liquid longest (assuming equal metal sections throughout the casting). The whole of the metal in the mould having passed through that part of the mould nearest the runner, the walls of the mould in that region are considerably heated by the time the

mould is full. The parts farthest from the runner solidify first, making up their loss of volume by shrinkage from the hotter portions nearer and nearer the runner, the latter, with its head of metal, serving as a reservoir for that purpose. In a casting of thin section this sequence takes place very rapidly. If, however, a fairly large casting having been poured, the runner head be closely watched for a minute or so after pouring has ceased, it will be seen that the level of metal in the head is falling. This may be observed more readily if a series of moulders' sprigs be pushed, prior to casting, into the side of the runner basin. Some one of them will then serve as a datum line from which to measure the fall of metal in the head. It should be remembered, however, that, in some cases, especially in green-sand work, solidification has taken place in some degree in parts of the mould before pouring has ceased, the shrinkage loss being at once made up. A compensating factor for liquid shrinkage is found in many important castings in the expansion of

Fig. 23.—Unetched × 75 dias.—Centre.

cores, which tend to swell immediately they are enclosed in the hot metal and pressing on the yielding metal. This is so pronounced in some cases that metal is squeezed up through the riser or runner. This, of course, can be prevented by pouring water on the head immediately pouring has ceased.

There are many important kinds of castings, however, which do not lend themselves to a complete natural feeding from the runner. Even though the designer has so far considered the foundry as to provide for equal cross-sections throughout the casting (which seldom happens; indeed, can seldom happen, for machining allowances increase the thickness of some sections as cast), the necessary joining together of wall with wall, each re-entrant angle calling for fillets, tend to leave pools of liquid iron cut off from any means of feeding. The remedies which lie to the hand of the foundryman are the judicious use of chills, and, where possible, the feeding rod or head. If there is a continuous channel from the heavy portion to the runner, which remains open to the last, freezing nearer and nearer to the runner, then it should feed solid naturally. If a frozen wall intervenes, then the remaining liquor must lose round about 1.5 per cent of its volume in solidifying. This may mean an irregular cavity in the section, or it may show itself in a very open, porous structure, which leaks under light pressure.

Steam Chest and Liquid Shrinkage.

Consider the casting, a steam chest, shown in Fig. 8. The engineering trade needs many types of casting much more difficult than this; but it will afford room for serious consideration of the problem referred to above. From the whole of the surface of the bottom of the casting, as shown in the sketch, 3-16 in. is machined off and the face highly polished. The castings are tested by the water test at 250 lbs. per sq. in., followed by a steam test at 130 lbs. The places at A and B are where trouble sometimes shows itself. The skin at C is never broken, and no trouble is ever experienced. These are the spots, however, where the experienced foundryman would look for danger. When such a casting has been poured, solidification proceeds from all faces inwards to the centre of each section concerned, at a rate commensurate with the speed with which heat is abstracted from each such face. The isothermal lines, however, are not parallel to the faces concerned at every point, but are as shown in the cross-section shown in Fig. 8. Where heat is being conducted from two faces at a large angle, as at B and C, solidification has proceeded considerably on those faces before the metal at the fillet begins to solidify. Where the angle is acute, as at C, that tendency is much more pronounced. Consequently, at a certain stage in the cooling of this casting the areas represented by the unlined spaces at A, B and C are still liquid when the remainder of the casting has solidified. If at this stage there is a continuous channel still liquid to the hot runner, or any alternative head of metal, they should feed solid naturally. If, however, they become isolated by a frozen section intervening, then, whatever material the mould may be made of, the remaining liquor must lose round about 1.5 per cent. of its volume in solidifying. This may mean an irregular shaped cavity, or it may show itself in a very open, porous structure. This last view will be further considered in connection with the ideas which have become associated with the name of M. Ronceray. Before leaving this part of the subject, reference might be made to the view, which appears to be widely held by Continental foundrymen, and in less degree by some of our own foundrymen, which tends to discount the importance of liquid shrinkage in cases like the one detailed above, finding the explanation in the failure to vent the cores properly, cavities and porosity being assumed to be due to gas from the cores. It has always seemed to the writer that the advocates of this view should inform us what has become of the metal which presumably occupied the space afterwards occupied by the gas. Take, for instance, the corner of the core at A, Fig. 8. If there were any tardiness in getting the vent away from that part of the core, it would show itself at an early stage, as soon as cast. The bubbles would at once pass to a higher part of the mould, and, if they could not pass out of the casting, would later be found there. As each bubble left the point the space would immediately

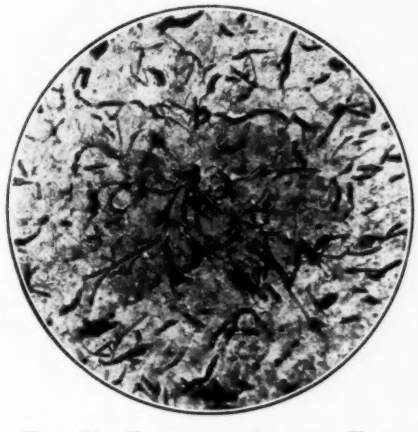


Fig. 24.—Etched × 75 dias.—Edge.

be re-occupied by fluid metal. This can be imagined as continuing until the metal above became too pasty to allow of the passage of more gas. At some stage of this process, however, the escaping gas at the point A would have to discharge itself into an area already fully occupied by metal, which, though liquid itself, was surrounded by frozen walls. What, then, becomes of the metal which was in the space which is said to have been occupied by gas? It seems to the writer that liquid shrinkage affords a truer explanation of the weaknesses found at such places. Whilst faulty venting of cores is the cause of a good deal of trouble in castings, it can be saddled with too much responsibility.

No discussion of the problem of liquid shrinkage would be complete without consideration of the important contribution made to its solution which

has been voiced by M. Ronceray. The principles which he has laid down are, in the writer's opinion, capable of very useful application, and the industry is his debtor. He has, however, said[10] that he would expect no casting to shrink on solidification if run with filter gates of a maximum cross-section of 3 ins. or less. Now, if molten iron which is cast into a $5\frac{3}{4}$ ins. dia. sphere, cast in drysand, shows a void of 2.4 per cent. of its volume, there seems no reason why a smaller section should not shrink in a similar ratio. The writer's view of the process of solidification has been given above. A few experiments with slow pouring will be detailed.

Feeding can be Eliminated in Small Castings.

Fig. 9 gives details of a worm gear blank, machine moulded and jointed at A. A photograph of the finished article is shown at No. 1, Fig. 20. These are cast four in a box. Many ways of running these castings were tried, but difficulty

Fig. 25.—Etched × 700 dias.—Edge.

was experienced in getting them free from spongy places in the worm and inside the bore. To feed a day's work of these castings is more than a nuisance. There are not many men who will take the trouble to feed a lot of small castings conscientiously. Finally, the writer put on a disc runner, as shown at C, Fig. 9, each mould being filled with metal through a slit not more than $\frac{1}{8}$ in. at its widest, tapering away at each end to nothing over a distance of $\frac{3}{4}$ in., as shown at B. Many hundreds have been cast in that way without a single rejection from the machine shop. The principle involved is that advocated by M. Ronceray.

The pinion, with cast teeth, shown at No. 4, Fig. 20, was equally successful. These castings had hitherto been cast by means of a $\frac{3}{4}$-in. runner, placed on the boss (which is rather heavy), through which each casting was fed. In spite of this, however, many of them were found spongy on boring. A $\frac{3}{4}$-in. dia. runner was tried on the rim (the white spot on the rim of No. 4, Fig. 20) and the feeders were dispensed with. There was also no riser. There was no further trouble with this casting, and the laborious work of feeding was not necessary.

A Casting Requiring Feeding.

In the case of the gear blank, shown at Fig. 10, the results were unsatisfactory. If cast in the ordinary way, it is imperative that it should be fed. A spongy place very often is found at A, after boring, or B, when the teeth are cut. Slow pouring was tried. A small runner through the core, as shown, was tried, but a depression of varying depth was found in the top face, as shown in the sketch. A $\frac{1}{16}$-in. pencil runner on the top was tried, with the same result. A filter gate containing two $\frac{1}{4}$-in. dia. runners was tried, with a similar result. In addition, the metal had shrunk away from the core at C. A pencil runner was placed at the bottom of the casting, as shown in the sketch. The result was similar. In most of these cases, however (and they were tried several times each) the depression was fairly well distributed round the top, which depressions, not being deeper than a $\frac{1}{16}$-in. machining allowance, allowed the castings to clean up. They were found to be quite solid.

Reference was made earlier to the casting of the cylindrical block by slow pouring, run off level at the joint. It was shown to shrink not less than in other cases. A further experiment with the block was tried. A mould was made with no riser and a heavy down runner leading to the casting by a $\frac{1}{4}$-in. dia. runner. Head metal was provided to a height of 13 in. above the top of the mould. It was cast with hot metal. When the casting was taken out the middle of the top was depressed to a depth of $\frac{1}{8}$ in. An inch-diameter hole drilled through the centre revealed a large cavity.

Distribution of Liquid Shrinkage.

It appears to the writer that the difference between a slowly poured casting and one poured in the ordinary way is not that the total liquid shrinkage is diminished, but that it is distributed in a different way. In a casting poured in the ordinary way, the total shrinkage may show itself in a cavity at some "hot spot," the last place to solidify. Slow pouring means quiet pouring. When a casting is poured rapidly, it is probable that currents are set up which circulate throughout certain regions of the liquid in the mould, and that the momentum is not lost for a considerable time. This may accentuate uneven crystallisation—in point of time, *i.e.*, it may be that in certain parts of the casting, being without eddies, primary crystallisation may begin before that in the hotter, agitated portion. Thus local crystallisation would proceed, all its requirements of mother liquor being met—at the expense of the remainder of the casting if new metal did not enter the mould. On the other hand, the casting run with filter gates would fill very slowly. There would be very little agitation of the metal. There would be no riser, the pouring would be the sooner complete, and the metal at rest almost as soon as

Fig. 26.—Etched × 75 dias.—Centre.

cast. What then happens? Consider the following, by Professor Tschernoff[11] on the crystallisation of salts: "When studying under the microscope with high magnification the formation of salt crystals as they separate from their solutions, we note that the growth of crystals from their nuclei manifests itself in a rapid, nearly simultaneous appearance of axes, branches, and even planes, starting in definite directions in accordance with the crystallographic axes of the growing crystals. From the principal axes will branch off axes of the first order; from these, axes of the second order, and so on. This takes place in so rapid succession that it is impossible to trace the formation of every individual branch. The rapidly forming branches gradually thicken and elongate, and as a result meet neighbouring branches and grow together."

That cast iron, when solidifying, behaves very similarly is probable. Every foundryman knows that, when a casting is being fed with a rod, there comes a moment when it feels to the hand as if the rod were snapping off innumerable microscopical carrots. At this stage the metal feeds away very rapidly into the casting, this being, in fact, the effective feeding stage. If, then, it be

imagined that something of a similar character takes place in solidifying iron, the following may be the sequence of events in the case of a slowly run casting. The mould fills with relative quietness. Cooling takes place from metal to mould walls, and from the centre of the metal to the outside. Before crystallisation can begin, the metal must be undercooled. In this case (if the mass is not too great), before crystallisation seriously commences, the whole of the metal in the mould is probably below main freezing point. Consequently, in a quiet medium, the whole of the metal, at a given moment, may be intersected in every direction with the axes, branches and

FIG. 27.—ETCHED × 700 DIAS.—CENTRE.

planes of elementary crystals. The formation of these elementary crystals will cause a demand for mother liquor. The skeleton structure only having been formed, gravitation may induce a feeding downwards, thus explaining a shallow depression on the top of the casting. Crystallisation is proceeding, however, very rapidly, the branches quickly thicken, elongate, meet neighbouring branches, and grow together. Any deficiency of mother liquor is now equally distributed, the process taking place so rapidly that shrinkage takes the form of intercrystalline spaces. These spaces may not be seen with the naked eye on a planed or polished surface, but may be found by the aid of the microscope. Thus, in the writer's opinion, is the relative freedom from shrinkage cavities obtained by slow pouring—that is, of course, in addition to any advantage obtained from the partial solidification which may have taken place in some part of the casting before pouring is finished. Admittedly the foregoing is hypothetical. If true, however, it would afford some explanation of the relative success of slow pouring. The writer is aware of no other explanation, certainly none has been put forward, even by M. Ronceray.

The experiments detailed above were limited to what may be fairly described as average foundry irons. No high-phosphorus irons were tried, nor were any very low-silicon irons. From Professor Turner's work it is probable that the phosphoric irons would show a different result, *i.e.*, the shrinkage may be fully compensated for, in suitable circumstances, by post-solidification expansion. On the other hand, with much lower silicon irons the post-solidification expansion would probably be less, thus making for a greater residual shrinkage.

The writer is indebted to the manager of the Kilbowie Laboratories, Mr. R. K. Tullis, for the analyses and microphotographs, and to Messrs. D. & J. Tullis, Kilbowie Ironworks, for permission to carry out the experiments detailed above.

Conclusions Deduced.

With respect to the grey irons which were tried, the writer reaches the following conclusions:—

(1) Grey iron shrinks round about 4.5 per cent. of its liquid volume on crystallising.

(2) If the expansion which immediately follows crystallisation be directed wholly inwards there is a residual loss of volume, due to liquid shrinkage, of round about 1.5 per cent.

(3) Quick cooling (as by the use of chills) does not reduce the rate of liquid shrinkage, but makes for greater solidity only if solidification is so speeded up thereby as to enable new metal to reach the part concerned.

(4) Slow pouring does not reduce the rate of liquid shrinkage, but may alter its distribution throughout the casting.

(5) The aggregate loss of volume, due to liquid shrinkage, does not appear to be appreciably affected by composition or temperature of pouring.

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2 Phil. Mag. Vol. XI, 1881, and Vol. XIII, 1882.
3 Cast Iron in Light of Recent Research, p. 112.
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6 Jour. Inst. of Metals, No. 2. Vol. XXX, p. 133, 1923.
7 Jour. Iron and Steel Inst. Vol. I, p. 48, 1906.
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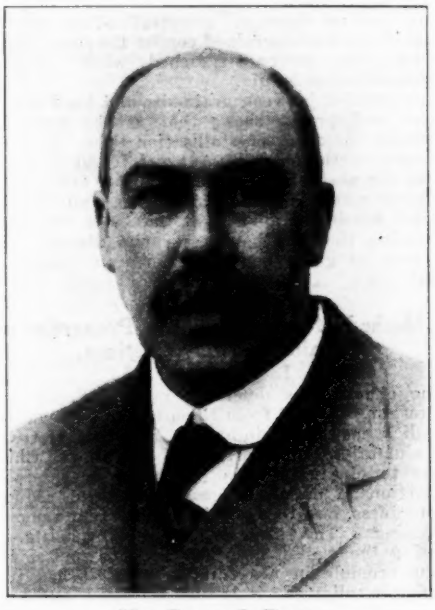
Refractory Association's New President.

Mr. Frank J. Boam, whose photograph we give below, was elected President of the Refractories Association at the general meeting held last Friday in Sheffield. Mr. Boam has extensive silica sand



MR. FRANK J. BOAM.

The newly-elected President of the Refractories Association.

quarries at Middleton and Gayton Road, near King's Lynn. He conducts his business, however, from 35, Silver Street, Leicester. He is the fourth president of the Association, and the inception of his chairmanship was marked by the presentation of a chain of office, the gift of Mr. Frank Russell, the retiring president.

THE SHAREHOLDERS OF Parkinson & W. and B. Cowan, Limited, have been offered an issue of preference and ordinary shares this week. The company and its subsidiaries operate 16 factories in Great Britain and Ireland, and six in Australia and Canada, while connections have been established in other parts of the world. Important extensions now under way are expected to add largely to both turnover and profit. During the first half of the current financial year sales of gas stoves, meters, etc., showed a 40 per cent. increase and are being well maintained. The company has some debentures in issue, and there are outstanding £208,841 of an authorised amount of £400,000 in 7 per cent. cumulative preference shares, together with £425,871 of an authorised issue of £600,000 in ordinary shares. The present offer consists of 100,000 preference shares and 50,000 ordinary shares, the latter being offered, in the first place to existing shareholders, at 20s. each, subject to the return to subscribers of 1s. per share by way of commission when the shares are fully paid.

Institute of Metals.

The spring meeting which opened yesterday under the Presidency of Professor T. Turner had presented to it a number of Papers of indirect interest to foundrymen. Below we give summaries of the Papers presented.

The Effect of Grain-Size Upon Hardness and Annealing Temperature.

By H. T. Angus, M.Sc., and P. F. Summers, A.R.S.M.

It is shown that the grain-size of a metal just before rolling considerably affects its hardness when annealed after rolling at temperatures up to the recrystallisation temperature. It is well known that many heavily-worked metals increase in hardness on annealing for a short time at relatively low temperatures, and this property is shown to depend, among other things, upon the grain-size that existed at the time of rolling. A coarse grain-size increases this rise in hardness and the range of temperature over which it extends, whereas with a fine grain-size softening may commence at much lower temperatures. This effect was noted in both pure copper and bronze containing 4.5 per cent. of tin. It was also observed that the recrystallisation temperature of copper is higher in the coarse-grained metal than in the fine-grained, in which almost complete softening occurs before signs of recrystallisation appear; while in the coarse-grained copper the same degree of softening is only reached when complete recrystallisation occurs.

The relation between grain-size and hardness for copper and bronze shows that as the grain-size increases after recrystallisation the hardness decreases correspondingly. It was found by calculating the area of grain boundary per cubic millimetre of metal from the grain-size, and plotting against hardness, a straight line was obtained, indicating that the hardness varies directly with the area of grain boundary per unit volume of metal.

A Method of Improving the Properties of Aluminium Alloy Castings.

By S. L. Archbutt, F.I.C.

The experiments described in this Paper and the results obtained from them are to be regarded as indicating the possibilities of a method of treating aluminium and certain of its alloys, which serves to eliminate at all events a considerable proportion of dissolved gas and thus reduces unsoundness, and to a considerable extent removes pin-holing. The process suggested consists in allowing the molten alloy or metal to cool slowly in the crucible in the furnace until it has just completely solidified; it is then remelted, and may be carefully stirred, raised to the pouring temperature, and cast. Ingotting the metal is not satisfactory, as the ingots cool too quickly, and during remelting are too much exposed to the furnace gases.

In a later experiment described, passage of an inert gas through the melt during slow cooling and solidification has been found to improve still further the soundness of resulting sand-cast bars.

Slightly anomalous results have been obtained in some cases, and it is not yet clear how far the method is of value in other alloys, whether consisting mainly of aluminium or of other metals. It is evident that much further investigation is required. Meanwhile, the author has learnt that simultaneously and independently Professor C. A. Edwards and Mr. W. E. Prytherch, of Swansea, working on the effect of gases in copper (for the British Non-Ferrous Metals Research Association), have discovered a similar effect obtained by solidification in the crucible in the case of pure copper.

Surface Abrasion as a Potential Cause of Localised Corrosion.

By Uiick R. Evans, M.A.

Previous work has indicated that most cases of serious corrosion are of an electrochemical character; for electrochemical action usually gives rise to soluble primary corrosion products, whilst direct chemical oxidation would generally produce an insoluble body *in situ* on the metallic surface, which would tend to obstruct further attack. Bengough has indicated that local abrasion—by causing removal of the obstructive film—may allow local attack, whilst von Wurstemberger has suggested that very severe corrosion may be occasioned by electric currents flowing between the bare abraded portion and the still encrusted area.

An experimental investigation has been made regarding the existence of these currents. Sometimes they flow in such a direction as to localise corrosion on the small abraded portion, sometimes in the contrary direction. But they are generally transitors, dying away soon after abrasion ceases. Moreover, the abrasion required to produce these currents must, in most cases, be sufficient to damage the metal by mechanical erosion also. In the case of the corrosion of zinc by hydrochloric acid the wiping away of the black scum of residual impurities (lead, etc.) actually diminishes the rate of attack; the impurities, if allowed to accumulate, act as the cathodic members of the corrosion-couples and facilitate the liberation of hydrogen. Vernon's statement that commercial (impure) zinc is attacked more slowly than some grades of much purer zinc is, however, confirmed; probably "homophase" impurities (in solid solution) behave in the opposite mode to "heterophase" impurities (present as a separate phase).

The Influence of Emulsoids Upon the Rate of Dissolution of Zinc in Solutions of Lead, Nickel and Copper Salts.

By J. Newton Friend, D.Sc., Ph.D., F.I.C., and J. S. Tidmus, B.Sc.

Experiments carried out since 1921 have shown that the presence of emulsoids, such as gelatin, starch, etc., exerts a marked retarding influence upon the course of many chemical reactions, such as the rate of solution of metals in acid, the corrosion of metals, the rate of solution of salts in water, and of iron in aqueous solutions of inorganic salts, such as lead acetate and copper sulphate. The results appeared to justify the enunciation of a general law of retardation, according to which:—

Emulsoids tend to retard the velocity of such reactions, whether chemical or physical, as involve a change of state from solid to liquid, or vice versa, *in one or more of the components.*

This retardation is, in the main, due to adsorption; that is, it is a surface phenomenon, a thin layer of the emulsoid collecting upon the surfaces of the solid reactants, thus impeding their chemical activity.

The present Paper is more particularly concerned with the rate of dissolution of zinc in lead acetate, nickel sulphate and copper sulphate solutions, under varying conditions, and it is gratifying to note that the results harmonise with those previously obtained, and confirm the retardation law.

One result of considerable interest is the fact that the retarding action of the emulsoids frequently falls off markedly with rise of temperature. This is of practical importance as illustrating the fact that remedies which yield satisfactory protection to metals at ordinary temperatures will not of necessity prove equally efficient if the temperature is raised.

Comparative Tests on Some Varieties of Commercial Copper Rod.

By T. G. Bamford, M.Sc.

The primary object of the research was to compare the properties of certain distinctive varieties of commercial copper, with a view to ascertaining their relative durability under conditions which they would meet in service, particularly as constructional parts of locomotive fireboxes. Three deoxidised and two "tough-pitch" coppers were tested. Of the former, the first contained 0.31 per cent., the second 0.53 per cent. of arsenic, while the third contained 1.5 per cent. of nickel, and but a trace only of arsenic. Of the "tough-pitch" copper one contained a trace of arsenic, while the other contained 0.45 per cent. of this element.

It was found that the phosphorus present in commercial copper which has been deoxidised with this element does not impair the mechanical properties of the metal. Three lots containing up to 0.2 per cent. of phosphorus were extremely strong, quite ductile, and more resistant to alternating stresses than "tough-pitch" varieties which were free from phosphorus. Deoxidised low arsenical, high arsenical, and 1.5 per cent. nickel-copper containing up to 0.014 per cent. of oxygen withstand severe gassing treatment, which would ruin "tough-pitch" metal. Deoxidised copper containing 1.5 per cent. of nickel is more resistive to harmful influences arising from severe heating in either reducing or oxidising atmospheres than are either "tough-pitch" (arsenical or non-arsenical) or deoxidised arsenical coppers. Actually the tensile strength of this nickel-copper is vastly improved, its hardness greatly increased, no brittleness is developed, and it preserves a high ductility after severe gassing treatment.

The nickel-copper containing 1.5 per cent. metal oxidises less rapidly than any other variety tested. The "tough-pitch" and the deoxidised varieties, not containing nickel, oxidise approximately to the same extent, but when the "tough-pitch" varieties scale the oxide penetrates into the metal—more particularly so in the case of non-arsenical "tough-pitch" copper, on which a very rigidly adherent scale is formed. It follows that "tough-pitch" non-arsenical copper will give most trouble in hot-working operations where it is desired to avoid entanglement of scale in the metal. The resistance which 1.5 per cent. of nickel-copper possesses to gassing, as well as its augmented hardness and strength resulting from high-temperature treatment, render it very suitable for engineering, and particularly for locomotive parts.

The Alpha Phase Boundary in the Copper Zinc System.

By R. GENDERS, M.Met., and G. L. BAILEY, M.Sc.

In view of evidence indicating inaccuracies in the position of the alpha phase boundary as given by Shepherd and modified by Matthewson and Davidson and others, the authors undertook complete revision of this portion of the diagram. The method adopted was that of quenching the alloys, after annealing to equilibrium, at successive intervals of 20 deg. C. in the neighbourhood of the phase boundary. Subsequent micro-examination was made to determine the lowest temperature at which traces of beta appeared, and those temperatures were determined over the range 61.1 to 67.7 per cent. copper on seven alloys at intervals of approximately 1 per cent. copper. The preliminary annealing of the alloys to all alpha presented no difficulty where the copper content exceeded 62 per cent., but the long annealing required for alloys of lower copper content was avoided by first quenching the specimens in the beta range and reannealing at 450 deg. C., at which temperature equilibrium was reached within a short period—one hour in the case of the 61.1 per cent. alloy. The data obtained from this work require a movement in the solubility line to the right of that given by previous workers. At 470 deg. C. the boundary reaches a low limit of concentration of copper at approximately 61 per cent., and this figure seems to be unaffected to any appreciable extent by further fall in temperature. Above 470 deg. C. the solubility decreases with rise in temperature, and the junction of the alpha boundary with the solidus is shown at a concentration of 67.5 per cent. at a temperature in good agreement with Parravano's determination of the peritectic temperature at 905 deg. C. The commencement of the peritectic transformation at 67.5 per cent. copper is confirmed by a determination of the solidus for an alloy containing 70 per cent. copper, which first showed traces of liquid at about 913 deg. C.

The Influence of Lead and Tin on the Brittle Ranges of Brass.

By DENIS BUNTING, M.Sc., Ph.D.

The influence of two impurities, lead and tin, on the brittle ranges of brass has been investigated. It was found that the chief effect of lead was mechanical; the brittle range in itself was not affected, but masked owing to the embrittling effect at other temperatures of the lead, which segregated as globules to the grain boundary. β brass was very susceptible to this deleterious effect; $\alpha + \beta$ brass was also affected, but not to the same extent; whilst α brass appeared to be immune from this intercrystalline weakness caused by small percentages of lead.

The effect of tin can be considered under two headings: tin in solution and tin in excess of the solubility limit. Tin in excess of the solubility limit produced extreme brittleness owing to the production of the brittle gamma or delta constituent. The effect of tin in solution appeared to be connected with an increase in crystal rigidity. The β and $\alpha + \beta$ (β matrix) brasses were rendered more brittle at low temperatures, and the brittle range so increased, whilst the impact strength of the α and $\alpha + \beta$ (α matrix) brasses was improved, and so the brittle range is consequently decreased.

The Removal of Red Stains from Brass.

By E. A. BOLTON, M.Sc.

Various considerations affecting the oxidation and staining of brass are reviewed, and the author's earlier work is confirmed, and, in addition, the difficulty of avoiding staining with brass of high copper content is described. The theory of staining occurring by reaction between cupric oxide and the pickling acid is described and attributed to concentration cell action. Electrochemical difficulties in stain removal are shown. Attention is turned to the use of solutions containing sulphuric and nitric acids for stain removal. While such solutions show some possibility of success, results are not so favourable as those obtained with solutions of dichromate and sulphuric acid. The action of these solutions is explained and described in detail, and, as a result of the research, details are given suitable for the development of the process upon the industrial scale.

The Density and Constitution of the Industrial Brasses.

By G. L. BAILEY, M.Sc., and R. GENDERS, M.B.E.

Values have been obtained for the crystal density of the brasses in equilibrium over the range of composition used industrially. The effect of coring in α brasses on the net density appears to be negligible; the alloys which contain β in the chill-cast state, however, have a small range of variable density due to the difference in density between α and β, and the density of sound castings may vary according to the amount of β produced by the particular conditions under which the alloy was cooled from the liquid state to temperatures within the region of 450 deg. C.

An alloy always consisting entirely of β is unaffected in density by heat-treatment, and it is apparent that whatever the nature of the transformation at 470 deg. C., either there is no accompanying volume change, or the transformation is not suppressed by any ordinary method of quenching.

The differences which have been observed by Bamford and other workers between the densities of sand- and chill-castings are considered to be due to the presence in the sand-castings of fine porosity consisting of interdendritic cavities.

A phenomenon not previously observed by the authors in any alloy, consisting in a reduction of density, due to unsoundness accompanying constitutional change (β to α), has been found to occur in the brasses over a considerable range of composition. The unsoundness produced is removable either by reversing the constitutional change (as by quenching) or by mechanical compression.

From a practical point of view, it is of particular interest that heat-treatments, involving quenching of the α β brasses and a small range of the α brasses, may give rise to internal stresses of considerable magnitude, consequent on constitutional changes taking place during quenching. The cracking of heat-treated articles which sometimes occurs appears to be attributable to constitutional volume change rather than to the difference between the expansivities of the different constituents.

XUM

Note on the Effects of Certain Elements on the Electrical Resistivity of Copper.

By A. L. Norbury, M.Sc.

In the first part of the Note some new data are given for the electrical resistivities of certain alloys of copper, containing low percentages of each of the following added elements in solid solution:—Aluminium, silicon, manganese, nickel, zinc, silver and tin.

From these results, and from those obtained by previous investigators, values for the "increase in the electrical resistivity of copper due to the presence in solid solution of 1.0 atomic per cent. added element" are calculated for each of the added elements. The results so obtained show that the "atomic effects" are small for elements like silver and gold—which are in the same group as copper in the Periodic Table—and are progressively larger as the added elements are further away from copper in the Table.

It is suggested, therefore, that the "atomic effects" are large or small according to the "affinity" between atoms of solvent and solute is large or small.

On the Density of Rhodium.

By Sir Thomas Kirke Rose, D.Sc., A.R.S.M.

Two specimens of rhodium were kindly prepared by Messrs. Johnson and Matthey for the purposes of the investigation, one being forged up from sponge and annealed but not melted, and the other melted from sponge in the oxyhydrogen blowpipe and forged while hot. The rhodium sponge was chemically pure.

The density of the melted specimen was found to be 12.47 in vacuo at 0 to 4 deg., but the other specimen was evidently not free from internal cavities, as its density was only 12.22. Previous determinations by other observers had given 12.1 to 12.6, but were unsatisfactory owing to various causes.

Defective Valve Castings.

Progress in foundry practice would stop were it not for occasional wasters. A great deal is heard from engineers and others about the desirability of making the founder's art an exact science, but given the most perfect equipment, the most highly-skilled labour, and scientific control of melting, and there will be occasional wasters. Were it not for these wasters the foundry would be a less interesting place. Even in a repetition foundry there is an element of uncertainty in the casting of every job, and a slight deviation from established practice will mean the presentation of a fresh set of problems. The writer had a very interesting experience recently with a number—about fifty—of valve castings. In the production of these castings every precaution—apparently—was taken to ensure their soundness, and it was not until after they were machined, and when they were under test, that they were found to be defective.

The valve was a form of globe valve with a branch at right-angle to the main body. There were apparently no moulding difficulties involved. The inlet and outlet branches were of 6 in. diameter and the thickness of the metal a uniform ½ in. The pattern was of solid timber, as was also the corebox. Both were carefully checked before they left the pattern shop. There were three prints. It is, of course, a common practice with certain work, where chaplets are objectionable, to make a special core at a place where there is a probability of the main core sagging or floating, and afterwards plugging it. In this case there appeared to be no need for such a course.

A first casting was made and sent to the customer for approval. As soundness was essential, it was sawn into several parts and thicknesses carefully measured. There was neither porosity nor blow-holes, and the thickness was everywhere correct. The casting was altogether admirable. The foundry was instructed to proceed with the work, and, in due course, all the castings were delivered. After being marked off, they were sent into the brass-finishers' shop, and the flanges and valve seats were turned. The valve seats were fitted and the valves were tested. Every casting failed. There was—to put it very mildly—consternation. The valves were then measured up very carefully, and it was found that midway between the branches on the main body, at opposite sides, the metal varied in thickness by over ⅛ in. At one part it was about $\frac{1}{16}$ in., and at the opposite side it was about $\frac{3}{16}$ in.

As usually happens in such cases, the foreman patternmaker was consulted. As all the castings were more or less alike, it did not appear to be the foundry's fault. The pattern and corebox were very carefully callipered and checked over in every way, and found to be as accurate as they could be. The foundry was then communicated with. Another mould was prepared from the pattern and a core also made. The core was set in position and the job clay-thicknessed both on the bottom and the top. The thicknesses were correct.

It was next decided to make a casting from the mould which had been clay-thicknessed. The resultant casting was faulty, as were the others. The core had apparently floated when the metal rushed into the mould. Floating cores are common enough, but it did not seem a job of that kind. The obvious way to obtain good castings was to place a chaplet on the top. This was done, and the result was satisfactory. The customer, unfortunately, objected to chaplets, and the foundry foreman was in an interesting dilemma. It was at this stage that a moulder who had, up to this stage, been an interested looker-on, made a suggestion.

The core irons being used were of wrought iron. If, in this moulder's opinion, a cast core iron was substituted, perfect castings would result. He urged—from previous experience—that when the metal flowed into the mould the wrought iron yielded to the upward pressure, and the core therefore became warped. Examination of some of the grids seemed to bear this out. Using the same pattern and corebox and adopting exactly the same moulding methods—no chaplets being used—but with a strong cast grid, another casting was made, and it was an excellent casting in every way. It was thus proved conclusively that the wrought-iron grid was to blame. The other defective castings were replaced without more concern.

The lesson taught by this experience is, not that wrought-iron grids are inferior to cast grids, but that careful discrimination and judgment should be used. One of the recognised advantages of a cast grid is the comparative ease with which it can be snapped in convenient places and pulled out of a core. It is also often cheaper to make cast grids, especially when cores are of awkward shape, but wrought grids are, of course, stronger.

The foundry was wholly blamed for the batch of bad castings, and perhaps, up to a point, this was just. But, on the other hand, every precaution suggested by experience had been taken. Further, by a strange freak of chance, identical methods with the first trial casting had proved successful.

If engineers believe, as they repeatedly say they do, that foundries are different from machine and fitting shops, why do they not have every casting examined *before* being machined? The writer heard of another case recently, when a blow-hole, which caused the rejection of a casting, was only discovered after the bolt holes in a flange had been drilled. Yet the blow-hole was observable on the outside diameter of the flange. There in no sense in machining castings until they have been most carefully tested for defects. There are large foundries which have found it expedient to employ a man whose duty it is to examine all work before it is sent out. The result is that complaints from customers are rare. But only the largest foundries can afford to do this, and even then it is scarcely practicable on heavy and intricate castings.

The severe test should be on the marking-off table in the engineers' shop before a single face is machined or diameter bored. In some engineering shops it is customary to do this, and, whatever the cost of doing so, it is saved subsequently. If the foundry bears the whole reproduction cost, as in the case of the valve castings aforementioned, the engineer is delayed; both foundryman and customer therefore lose. J. D.

An Analysis of Defective Castings.*

By E. Longden, A.M.I.Brit.F.

(*Continued from page* 210.)

Lap or Crossed Joints.

Pattern dowels may become loose by ordinary wear and tear or unfair usage, such as rapping the dowel-pin to loosen the pattern. Moulders sometimes drop a rapping bar in a dowel hole to loosen the pattern because either no loosening plate was provided or it had become too free to fulfil its proper function. Insufficient or worn pins and pin-holes are a prolific cause of waste under this head. With bedded-in work, locating stakes may be incorrectly placed or loosened in various ways. In loam work, and sometimes when using moulding boxes, loam marks and flats are cut astride the joints before dismembering the mould and cores, when made together, for finishing, as when making intricate turbine and centrifugal castings, etc. Occasionally, after drying, these marks cannot be induced to correspond, due perhaps to careless handling when lifting with the chain slings, so that mould is strained, or the same trouble can arise if the tackle is too weak. Marks may be disturbed by moulder brushing them with his clothing or tools whilst they are green. The drying temperature of one part of mould may be more intense than another as the grains of sand on cooling do not quite return to their original position, and trouble is experienced in matching joints when assembling. When withdrawing a pattern, the mould may be disturbed about the joints, and the moulder fails to finish to the correct position. In snap-flask work, moulds may be disturbed when releasing the flask after closing or when placing the strain jacket around the sand. It is not unusual when moulder is lowering the top box to nudge the cores, especially if the pins be short or loose. Cores may be placed incorrectly or insecurely and moved when metal touches it, giving internal crossed joints. Weak core-boxes may, when sand is being rammed in, bulge, and allow a section of core to override another. Patterns are sometimes wrongly located on pattern plates. With plaster and white metal match plates, especially the latter, wear and tear and bruising may soon cause lap joints.

Cold Shut and Seams.

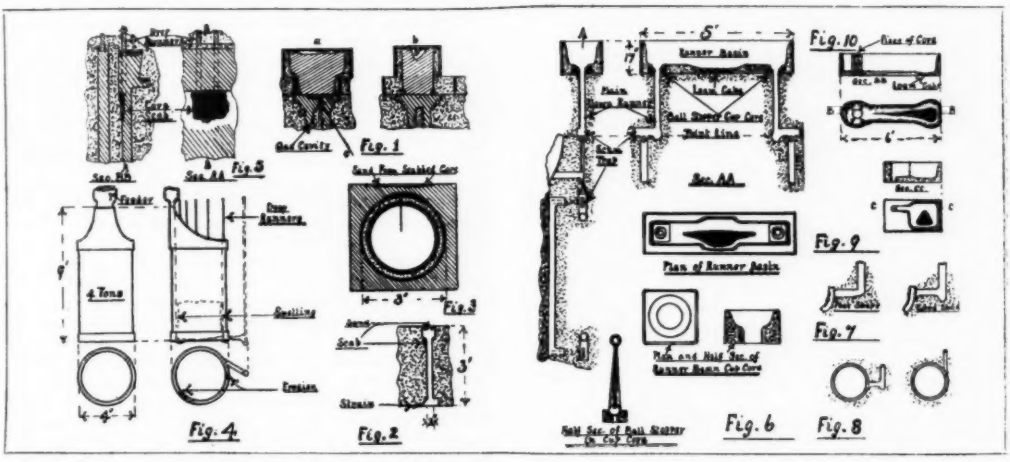
This fault occurs mostly in thin castings, especially if of considerable area, and can be caused by one or more of the following reasons:—Dull metal; shortage of runner gates or their bad location; arrest in the flow of metal due to either mould or core disturbance; carelessness in admitting the metal to the pouring basin; escape of metal from mould; the mould or core may blow; hard-rammed or sand with too much moisture; incorrect mixture of sand; a densener or chill may be too heavy for a given section of casting, or moisture may have formed on it; blacking and loose sand may run before the metal and form a parting; design of casting may present a very tortuous passage for the metal, so that it becomes oxidised on the surface and consequently sluggish and refuses to amalgamate with other streams of metal meeting from one or more directions; lack of fluidity in metal due to composition.

Abnormal Distortion and Fracture.

Camber is sometimes required or insufficient camber is allowed, in certain cases it may be quite the reverse to the right way. Cores may resist contraction, and casting either breaks or turns out much out of shape, especially when made in loam; cores, if not placed centrally in pipes or box-shaped castings, will produce uneven contraction and a bent casting. Failure to relieve runner and riser gates when close to the metal of box bars or loam plates gives trouble. A casting may be exposed too early after pouring. The cooling of heavy sections is sometimes neglected. Fin on mould joint or internally on joints of cores may give rise to cracks due to the rapid contraction of the thin section which pulls away from the heavier metal to which it is attached long before the latter has quite set; usually these cracks are only shallow. Heavy denseners, unless continued all over a given surface, may also cause shallow cracks. There are also castings which crack after an attempt to burn metal into a defective place. A bent casting is occasionally erroneously ascribed to distortion, when it is really due to a weak pattern bending. Metal, poured-dull, may cause excessive distortion or even fracture, especially along the line of a cold-shut or seam. The abnormal distortion is easily noted in long, plate-like castings when the camber has been determined with a desirable casting temperature which may be fairly high; pour this same casting with dull iron and camber is all wrong. Certain castings are so designed that it is almost impossible to produce them unbroken without an extraordinary amount of care and labour. Cases are on record where even a combination of camber, hastening cooling and metal manipulation both composition and temperature which failed to give complete satisfaction.

Faulty Repair of Mould and Cores.

When withdrawing a pattern from the sand portions of the mould are very often broken or disturbed. Extra metal is added to the casting if the repairing of sand is short; if the repair is too full or proud, the casting loses weight, and it sometimes happens that machining allowances are robbed or lost altogether and portions of the mould cut through thin sections. This happens occasionally when a section of a mould is stopped off or altered to meet various changes in design. Faulty repair also may mean pieces of mould or core being moved by the wash of the metal. Blow holes and scabbing are often due to faulty repair and finishing by introducing an excess of water, the

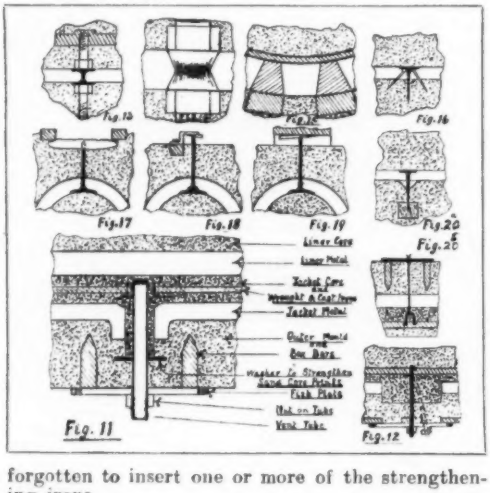


* A Paper read before several branches of the Institute of British Foundrymen.

pasting of sand over already-smoothed places and the lack of venting. When a difficult repair is needed the pattern is sometimes returned to the mould in so doing, especially if the pattern is old, much damage is done which more than counterbalances the help given by returning the pattern to the mould.

Failure in General Construction of Mould.

The strength and construction of a mould are sometimes faulty, and one or more of the following troubles may arise:—Pieces may drop from top side of mould due to insufficient gaggers, or the latter may be so placed that they add a burden, instead of helping to sustain the sand. Sand may be detached from projections and cods of material in which there is indifferent reinforcement; it may be that insufficient rods of metal have been introduced to bolster the sand or too many rods have been placed which causes sand to break up and shatter. Sand between the running gate and the mould cavity may burst and be pushed into mould —badly-formed runners or the ineffective reinforcement of the sand being the cause and the trouble happens mostly in deep moulds. Core irons may be too weak, especially in lengthy castings, and if the use of chaplets or studs is prohibited, the core bends, and if not a complete waster, a thinning and thickening of sections results, and perhaps unexpected distortion. It is not unusual for a core to fracture completely when metal exerts pressure, because the coremaker has



forgotten to insert one or more of the strengthening irons.

A case is on record where a heavy casting which, being made in an improvised sand pit, was lost because the metal found its way across the distance of 12 ft. into another pit.

Mistakes in Setting Loose Pieces of Patterns and Loam Boards.

Sometimes, in spite of ample guides, the moulder and coremaker omit to position loose pieces of the pattern according to instructions. Pieces are also wrongly located by:—Ramming out of place, after removing screws or pegs; insufficient guide on the pattern and core box; wearing away of the guides or if the mould has been lacerated by a poor pattern draw, perhaps due to the moulder forgetting to free the loose pieces, he may, if the mould is repairable, replace the loose piece, but not quite to its correct position. A very important part of the loam moulder's work lies in setting sweep boards and loose pieces, forming branches, flanges, lugs, bosses, etc. Occasionally the strickle board is not set correctly, which either gives a casting too thick or too thin. Loose pieces are also set wrongly when marks on boards become obscured, and perhaps because the moulder does not possess the symmetrical eye. Wherever possible the author strongly advocates the patternmaker overlooking the setting of loose pieces in loam moulds.

Indifferent Looking Castings.

Castings are rejected when they do not present a good finish and regular shape and can be attributed to:—Swelling on the mould and cores, perhaps because of the soft ramming of the sand or in case of loam cores abuse of hay and straw-wrapping or burning of the latter during drying; in very heavy castings formed in deep moulds, it is almost impossible to prevent swelling at particular parts of hand-ramming alone, so that the moulder reinforces the sand by laying pieces of wrought iron or pig to within 2 in. of the mould face, this precaution is not always taken, and a swollen casting results; marks showing up due to the unskilful use of moulders' tools on the sand, and many of the defects such as scabbing, lap-joints, burning on of sand, etc., as explained in previous sections.

Breaking of Castings.

Thin, and occasionally thick, castings are cracked by the dresser when he hammers the outside of the casting to disturb or eject the core. The dresser breaks castings also by delivering heavy blows at the wrong angle or when using a blunt tool. In some cases, when clearing a core, he may drive a chisel bar too heavily between a core iron and casting bursting the latter. The dresser, although not responsible, in the first place, may break in runners and risers, which may be due to:—Dirt about the gates; sponginess, which is quite common; poorly-formed and wrong location of gates; after pouring a casting, detaching the runner and riser-heads either too early or too late, or the runner and riser may be strained, due to resisted contraction in the mould. These are moulding errors.

Miscellaneous and Rare Causes of Defects.

The improper use of the feeding rod gives a substantial waste. A core is sometimes omitted from a mould. Bleeding of the heavy sections of castings may happen if the mould is released too early. Open sand plates may not be uniform in section if the sand bed is not level.

Perhaps some foundrymen are able to give an account of defective castings from rare causes; the author could cite many. A waste casting appeared to have scabbed; a closer examination showed that a seed had germinated sometime after mould had been closed pushing before it a portion of the sand face. It is not so unusual to find insects crawling out of the face of the mould after the pattern has been withdrawn. There was recounted a case of a moulder wedging down a straight-limber gagger instead of the chaplet stem alongside it. When raking out the core from a large jacketed-pipe, the dresser drew the attention of the foreman to two holes which he thought were not quite central. It was soon discovered that the holes referred to were not required. The moulder, when testing the thicknesses had forgotten to take out two pieces of clay. The casting was so urgently required that it was decided to plug the holes with studs, and quite a sound job resulted. After parting the sink head from the top of a large hydraulic cylinder a large cavity was disclosed. After a little inquiry and thought the foundry foreman remembered that, desiring to use the casting pit for another job, the following morning, he had caused the moulding box containing the casting, which had been poured only three hours, to be lifted from the pit and placed horizontally on the floor. Apparently the metal in the top portion of the casting and sink head had not finished freezing, and the act of laying down in moulding box had allowed some of the still molten metal to pour back from the casting into the cavity which had been formed in the head. It should be pointed out that metal was burnt into the defective place and the casting saved. The excellence of the burn is proved by the constant use of this particular casting over a period of years.

Unsuitable Metal.

The percentage of waste which can be attributed to metal, especially in grey iron, is not great, most of the conditions having been stated under preceding sections. It only remains to emphasise that castings are rejected in addition to the reasons mentioned, because metal may be too hard or soft, or is not homogeneous, due to bad coke and melting practice and to incorrect casting temperatures. Grey iron, although a complex mixture, is comparatively easily dealt with and suitable analyses are available for any foundryman who is able to use the knowledge.

If we were to arrange for all metals a percentage of waste which could be separated out and apportioned and stated as foundry technique

or metal the author would arrange them in the following order :—

	Foundry Technique. Per cent.	Metal. Per cent.
Cast Iron	... 95	... 5
Malleable Iron ...	... 80	... 20
Steel	... 70	... 30
Aluminium	... 85	... 15
Brass	... 95	... 5
Gun Metals	... 75	... 25
Bronzes	... 80	... 20

Percentage of Waste.

To state a reasonable percentage of waste for various classes of castings poured would be indeed difficult and could only be comparative. There are many factors to consider, such as :—Quality and availability of labour which affects certain localities and shops more than others; systems, as determined by the economics of the particular business; production by time rates or payment by results; accessibility to moulding materials and their quality, also metals and fuels, etc.

A 6 per cent. waste bill in one locality or shop might be a more noteworthy achievement than 3 per cent. in another. In the former case, in addition to points previously mentioned, they may be operating a system of payment by results, or labour is not so skilled and low-rated; whilst in the latter case time-rated, and highly skilled. The availability of highly-trained moulders is of the first importance. Good conditions of employment are not inconsistent with cheap and, at the same time, high-quality production.

Machinery will help partly to fill the gap made by the dearth of moulders, but foundrymen will still be compelled to rely on the human element for the bulk of the work done.

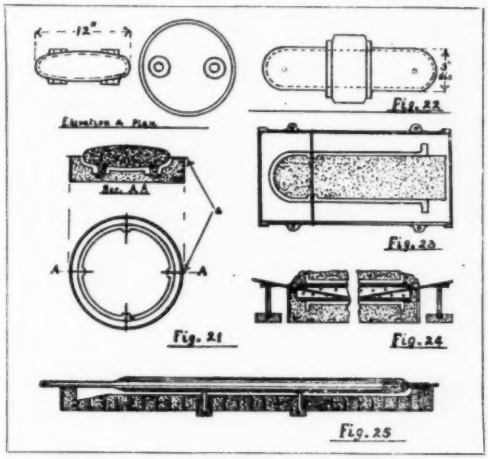
Britain still possesses the finest type of moulder in the world, but unfortunately, due to state of trade and other causes, the number of good moulders has steadily diminished.

Examples of Defects.

Fig. 1 gives an example of porosity due to gas, and also, as explained under the section dealing with abnormal distortion and fracture, the effect of placing a heavy feeder head to remedy the fault which, whilst helping to eliminate the gas porosity, introduced a defect quite as serious. It will be noted that the feeding head is quite close to the box bars. The casting, being much thinner than the feeder, contracted much sooner than the huge feeder which was prevented from following the movement of the casting and became slightly suspended between the bars. Many castings are lost in a similar way. Dressers are often blamed for breaking-in the gates when the moulding is at fault, as explained above.

Fig. 4 is a sketch of a liner, showing how erosion of the bottom side of a mould occurs when drop-gating from a height of about 10½ ft. This, of course, is due either to soft ramming, burnt mould, wrong mixture of sand or loam, or omitting to face-sprig these danger spots, which are struck as with a hammer blow. Sometimes it is possible to allow a small amount of metal to enter mould by way of a bottom gate, as shown by dotted lines in the sketch. This metal — first poured — forms a cushion to receive the bulk of the metal delivered by the series of top drop-gates. Such a way of gating is advisable with heavy liners, as the one shown, but for ordinary and medium sized liners no fear need be felt at running the whole of the metal through top drop-gates. This example also illustrates how a core can swell when hay or straw wrapping is burnt when drying, or the material mentioned is too near surface of core, as dealt with previously. The erosion of mould has also been explained. Fig. 2 illustrates points made when dealing with scabbing and shows how the face of a mould may expand and push a shoulder of sand into mould or metal, if the sand at this part is not sprigged. It also shows how a mould strains. Fig. 5 explains how scabbing can occur, as in the case of a large jacketted gas-engine cylinder, weighing three tons and caused by the metal, which was delivered through top drop-gates, impinging on the shoulder of sand. Fig. 3 is also mentioned in the section on scabbing and illustrates how a loam core can scab if last layer of loam is too thin and the underlying core has not been roughened. The metal when pouring around the core causes the outer skin of core to expand and buckle, as previously described.

In the section bearing the caption scabbing of moulds and cores is given an account of how cavity and porosity are caused by sand, etc. The sketches, Figs. 6 to 10, show a number of ways by which castings can be cleanly poured. Fig. 6 depicts a system for gating and pouring, horizontally, important castings such as steam cylinders. This method proved highly successful, hundreds being produced without waste. Let us follow the movement of the metal. After placing ball plugs in the cup-cores, the runner-basin, which holds about one-third of the total metal to be poured, is filled; the ball stoppers are lifted; the metal pours down two 3-in. dia. main runners and drops on to the dished-out place on the bottom joint of the mould; the scum gate quickly fills; this is helped by cores which have been placed across the intermediate flat down-gates leading from the joint, which are much less in area than the main



runners; the metal then passes quietly into mould through the in-gate, which is slightly larger than the intermediate runner.

Fig. 10 shows formation of pouring basin for such as flywheels, etc.; Fig. 9, a basin for pouring cleanly small important work without the aid of stoppers or plugs. Fig. 7, shows on the left a very poorly-formed runner gate which is altogether too common with indifferent moulders. The bottom of the down runner is subjected to the erosive action of the falling metal until the mould is filled. Sometimes this bottom portion scabs immediately metal falls on it and sand washes into the mould. Later, wonder is expressed as to why sand was found in the casting. The running-gate is quickly disposed of and so is the evidence. The right-hand sketch is a safer shape. Fig. 8 depicts on the left an indifferent way of gating pipes and box-like castings, and on the right a better way if a flange is not convenient.

Figs. 11 to 20 illustrate the various methods of securing cores to avoid the many defects described when dealing with core troubles. Fig. 13 shows how the single or double stud can be supported by bearers. Fig. 14 is a cast-iron stud used in certain types of heavy castings with sections ranging from 3 to 6 ins. and are used, especially if compelled, to place them near the wash of the incoming metal. Fig. 15 depicts another cast-iron stud made to support a round core in a heavy furnace column, which, due to its length, was made in two pieces, the section of metal being 2¾ in. to 4 in. The examples 14 and 15 show that the studs are again supported by iron bearers. In Fig. 16 is shown how the resistance of a nail can be increased by suitably placing the ordinary moulders' sprigs. Fig. 20a shows a block of wood bedded below the face of the sand into which is driven the nail. Figs. 17, 18 and 19 show common methods of securing chaplets. In the case of Fig. 17 the chaplet is secured by excavating a small amount of sand from around the top of chaplet and under bars of box in which

is poured molten iron just prior to the pouring of the casting and allowed to set.

In rare cases a core cannot be secured in the top part of mould by the ordinary studs, etc., until the mould is turned over for the purpose of closing, so that wire and sometimes a bolt is projected through the section of metal, as shown in Fig. 20b. Fig. 12 shows at the dotted lines, how a bolt is sometimes placed to hold a core down. In such a case one need not be surprised if the core lifts by the act of the bolt straightening itself somewhat when fluid pressure is applied. With certain types of castings the method outlined in Fig. 11 proves very satisfactory. The sketch shows how the jacket cores in a large twin gas-engine cylinder were secured and at the same time providing a very safe vent. In certain classes of castings, the use of studs, chaplets or nails, are not desirable. Figs. 21 to 25 illustrate how to avoid and minimise the use of chaplets, etc. Fig. 21 is a thin box-like casting subjected to steam pressure. For some time much trouble had been experienced with defective castings due chiefly to leaking around chaplets and studs which were placed under and above the core. Arrangements were made so that the cores

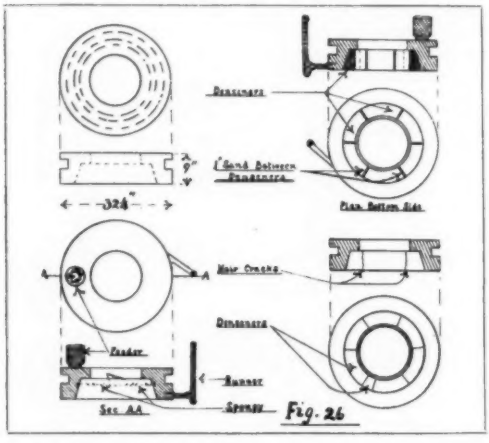


Fig. 26

could be made in oil-sand and to allow 6-in. sprigs newly cleaned and ground on the emery stone and placed in the cores, so that they stretched through the section of metal and sat astride the sand and metal joints. The method was highly successful because the cores were instantly located when placed in the bottom side of the mould and secured when the top part closed on the sprigs sitting on the joint. Fig. 23 is a similar case where a bar of wrought iron is stretched right across the core. Fig. 22 shows two castings made from one pattern by the use of the balanced core. In special pipes cores can be prevented from bending by using lever bars as indicated in Fig. 24. When making hydraulic rams of considerable length, say up to 35 ft., trouble is very often encountered by inability to keep core central. Due to its length core bends so much that it sits on the bottom of mould when coring up in the horizontal position, and when the box is lifted up vertically, the core fails to find the centre of the mould as intended. The author made rams twenty years ago and never failed to keep the core central by adopting the method depicted in Fig. 25, which is quite simple. Temporary wooden chaplets are inserted in and protrude through the bottom side of mould, lodging on a wrought-iron carrier attached to bottom of moulding box. In the core iron bearers are built to correspond with the wooden chaplets. The core is adjusted, the box closed and the mould lifted to the vertical position. Wooden chaplets are then taken out and the holes they leave plugged with a piece of core and secured by means of the carrier again. It will be noted that the core is bolted down at the bottom end, thereby allowing the core barrel to expand freely through top end of box.

Fig. 26 illustrates, again, gas porosity as described early in the Paper, but this sketch is shown chiefly to explain how shallow cracks are formed when using denseners over a large area. The cracks were due to splitting up the denseners, so that 1 in. of sand divided them. The trouble was overcome by continuing the denseners, which were made so that they could be easily knocked out of the casting while still hot. The whole of the mould, including the denseners, remained in the stove until ready for pouring.

It is advisable when commencing the production of a new type of casting, if it is comparatively small, to break up the first or even the second and third for examination.

When a system of moulding produces a minimum of waste it is inadvisable to alter until it has been proved that a different method is superior, or when cost can be reduced by placing for moulding by machine. Very often there is less waste from the moulding machine than from the jobbing floor.

Pulverised Coal.

A Paper upon the subject of pulverised coal was read by Mr. R. Jackson, of Coventry, at a meeting of the Manchester Association of Engineers on Friday last, in the course of which he remarked that in order to burn pulverised coal efficiently the following conditions should be fulfilled:—(1) The coal dust should be delivered into the furnace in a fine state of division and intimately mixed with the air required for combustion; (2) the particle should be of such size that it could be completely consumed in a definite period of time; (3) the velocity of the carrying air should be sufficient to sustain the coal particles; (4) the injection velocities into the furnace must exceed the velocity of flame propagation. The size of the particles was usually determined by the screening test, which was inexpensive and required only a simple apparatus. The apparatus used for the preparation of the fuel he divided into two classes: (1) The multiple or storage systems, and (2) the unit or self-contained systems. The former involved a comprehensive plant and were suitable for large fuel requirements. Capital cost was high, and special buildings had to be designed, but the increased efficiencies obtained and the ease with which the plant could be operated justified its adoption. It had been said that it could not be efficiently applied to medium or small fuel requirements, but in the last few years several efficient types of unit or self-contained pulverisers had been developed. Their chief advantages were compactness and the fact that usually no subsidiary power was required except for the rotating of the spindle and the provision of a raw-coal supply to the hopper. They involved no storage of powdered coal, which was used directly as produced. They were simple and easy to operate, occupied small floor space, and often could be accommodated in the space required for the withdrawal of chain stokers, and therefore did not involve separate buildings.

Since 1895, when pulverised fuel was successfully applied to the firing of rotary cement kilns, it had come into almost universal use for cement manufacture. Steady progress was also being made in its application to the firing of boilers and furnaces. Results obtained at Milwaukee and elsewhere showed that 85 per cent. efficiency from boilers only, and 90 per cent. when economisers were included could be obtained under suitable conditions, but some uncertainty had been felt whether similar results could be obtained from smaller boilers fired by unit-type pulverisers. The author submitted particulars of tests made with the Atritor unit pulveriser, which, he suggested, refuted the argument that pulverised fuel was unsuitable for firing small boilers. It had made substantial headway in the firing of locomotives, and if suitable colloidal fuels could be made by mixing pulverised coal with oil, without too rapid sedimentation, the problem of firing ships' boilers would be practically solved.

Association Technique de Fonderie.

Spring Programme.

The annual general meeting is to be held on March 31 at the offices of the Association, 15 rue Blue, Paris IX, at 3 p.m. The following lectures have been arranged:—March 18, "Defects in Small Malleable Castings," by M. Marcel Remy; April 4, "Pearlitic Cast Iron," by M. Bernard Baffet; (2) "Special Foundry Pig-iron," by M. J. H. Fleming; April 22, "A Study of the Handling of Materials in Foundries," by M. Jules Pillon.

Trade Talk.

THE DATE of the April Ironmasters' quarterly meeting at Birmingham has been altered to Thursday, April 2.

THE FIRST MEMBERS of the Steel House Constructors' Trade Union signed on from the ranks of the Unemployed Workers' League at a meeting at Leytonstone on Tuesday of last week. Already 600 men have joined.

THE IMPORTS of foreign iron ore at the Senhouse Dock at Maryport during February amounted to 7,600 tons, compared with 10,550 tons for January. No ore was imported at the corresponding period of last year.

JOHN THOMPSON WATER TUBE BOILERS, LIMITED, Wolverhampton, and allied companies, have appointed Mr. James Ritchie, of Glasgow, as their representative for Scotland. Mr. Ritchie's offices are at 50, Wellington Street, Glasgow.

THE INTERNATIONAL FOUNDRY EQUIPMENT COMPANY has been established at 132, Steelhouse Lane, Birmingham, for handling foundry patents in Great Britain, the Colonies, and the United States. Mr. G. C. Castle is the manager.

C. W. TAYLOR, LIMITED, have completed a number of large castings at the North Eastern Foundry, Tyne Dock, for the engines of the new P. & O. liners "Ranpura" and "Ranchi," which are being built at Hawthorn, Leslie & Co.'s yard. In the aggregate of the two sets of twin engines there are about 1,278 tons of iron castings, and it is understood they represent the largest set of reciprocating engine castings made on Tyneside. The heaviest of the bed plates weigh 32 tons.

HOWDEN - LJUNGSTROM PREHEATERS (LAND), LIMITED, are supplying one large preheater to Chance & Hunt, Limited, of Oldbury, near Birmingham. The total heating surface of the preheater is to be 17,500 square feet, air being supplied to the furnace at about 375 deg. F. : 12.4 per cent. saving in coal is guaranteed. The company have practically completed the installation of one air preheater on a Woodeson boiler at the Hull Corporation electricity works. The heating surface of the preheater is 26,680 sq. ft. Air will be supplied to the furnace at about 400 deg. F., and it is claimed that there will be a saving in coal of 13½ per cent.

MR. T. WESTGARTH, in the course of the annual prize-presentation at the Hartlepool Engine Works, mentioned that Richardson, Westgarth & Company, Limited, aimed to place on the market a two-stroke double-acting marine engine which would defy competition, both as regards cost of production and power developed. Experimental work on such an engine was going forward, and already some of the early patterns were in the foundry. The firm could not hope to compete, especially with foreigners, unless they could produce an engine less costly than the heavy four-stroke single-acting Diesel engine, which, for a given weight and size of cylinder, would develop equal or more power.

VICKERS, LIMITED, have received the order from the Associated Portland Cement Manufacturers for the three kiln shells each 250 ft. long, which will be the largest yet installed in this country, for Bevan's works. The condensing plant to be installed in connection with the new 6,000 K.W. Turbo set recently ordered by the Brighton Corporation is to be supplied by Vickers, Limited, Barrow-in-Furness. This constitutes a repeat order for a duplicate of the Vickers condenser put into commission in the same station last year. In connection with the power station extensions for the Poplar Borough Council, which are being carried out by Vickers and International Combustion Engineering, Limited, as main contractors, low pressure flash evaporating and deærating plant, is to be installed, and this will be supplied by Vickers, Limited, who are also constructing the condensing plant for the new 10,000 K.W. turbo set.

CONTRACTS OF THE VALUE of over half a million sterling have been placed by the London and North-Eastern Railway for 202 passenger carriages, including 6 complete articulated suburban trains of 8 coaches each with the following firms : Midland Railway Carriage & Wagon Company, Limited, 23 carriages and 3 complete suburban trains; Clayton Wagons, Limited, 20 carriages and 2 complete suburban trains; Metropolitan Carriage, Wagon & Finance Company, Limited, 40 carriages and 1 suburban train; Birmingham Railway Carriage & Wagon Company, Limited, 24 carriages; Cravens Railway Carriage & Wagon Company, Limited, 27 carriages; Hurst Nelson & Company, Limited; 5 carriages; the Gloucester Railway Carriage & Wagon Company, Limited, 10 carriages; R. Y. Pickering & Company, Limited, 5 carriages. All these carriages will be fitted with electric lighting and steam heating.

REMARKABLE feats of railway coach and wagon building are being accomplished at the various shops of the London Midland and Scottish Railway in connection with the £14,000,000 scheme of new construction and the standardisation of rolling stock. At the Wolverton works last year a plant was installed by means of which a covered goods wagon could be assembled in an hour and three-quarters; but the Derby works are now able to turn out 12-ton merchandise wagons at the rate of one every 25 minutes. In addition to the completion of the actual vehicle, this time allows for a first coat of paint. Vestibule passenger coaches are being assembled at the rate of one every half-hour. In this time, however, the upholstery is not included. By a new and cleverly devised system of gigs, the doors for these carriages are put together in less than a minute each, and careful standardisation enables them to be fitted, without adjustment, into any carriage doorway. For repair work these doors will be readily interchangeable.

Gazette.

MESSRS. G. F. GOZZARD and W. SCRAGG, metal merchants, 39A, New Street, Birmingham, trading under the style of George Bill-Gozzard, have dissolved partnership.

MESSRS. R. D. BREE, P. BREE and S. JUBB, electrical and general engineers, 33A, Ings Road, Wakefield, trading under the style of Bree, Jubb & Bree, have dissolved partnership.

THE PARTNERSHIP subsisting between Messrs. R. J. Williams and A. W. Vigars, carrying on business under the style of Thomas Williams & Son, at the Central Foundry, Smithfield Road, Aberystwyth, has been dissolved.

THE SUPERHEAT FURNACE COMPANY, LIMITED, Adolphus Street, Bradford, have been placed in voluntary liquidation, Mr. A. Ward, 21, Bridge Street, Bradford, and Mr. A. E. Stringer, Manor Row, Bradford, have been appointed liquidators.

LIEUT.-COLONEL H. GORDON LUHRS, general manager of the Wallsend works of the North-Eastern Marine Engineering Company, Limited, has been elected managing director of Henry Watson & Sons, Limited, engineers and brassfounders, Walker Gate, Newcastle.

Obituary.

MR. J. BUCHANAN, machinery contractor, 439, St. Vincent Street, Glasgow, died recently, in his 71st year.

MR. H. W. EDMUNDS has died at Southbourne, near Bournemouth, at the age of 78. The deceased gentleman in 1867 joined the firm of William Roberts & Company, Limited, merchants and hardware factors, Birmingham. Four years later he assumed full control, and was left as the sole surviving director in 1894, finally retiring from the business in 1910.

MR. J. HOTCHKISS has died at his residence, Victoria Road, Acock's Green, Birmingham, aged 86. He was the Consul for Nicaragua and Peru. Mr. Hotchkiss was one of the founders in 1877 of the firm of Warden & Hotchkiss, exporters of hardware, metals, etc., Birmingham, in connection with which he travelled extensively in Central and South America and South Africa. He retired from active business about ten years ago.

PROF. F. CRABTREE, who has died in America at the age of 52, was head of the department of mining and metallurgy in the school of engineering at the Carnegie Institute of Technology, Pittsburgh. He was born in Bramley, Yorks., in 1867, and went to the United States as a young man. At one time he was for several years superintendent of blast furnaces of the Colorado Fuel and Iron Company. Professor Crabtree was a member of the Iron and Steel Institute.

MR. J. G. STEWART died on March 1 at Ault Wharrie, Dunblane, aged 63. The deceased gentleman was chairman of Stewarts & Lloyds, Limited. He was the eldest son of the late Mr. A. Stewart, and his own career, culminating as head of the firm of Stewarts & Lloyds, of Birmingham, Coatbridge, and Glasgow, was one of equal credit and renown. He succeeded to the chairmanship of the company in 1901 on the death of his father, and to-day the business is one of the greatest of its kind in Europe. Mr. Stewart was also a director of Wilson & Clyde Collieries, and prior to the amalgamation of the companies he was a director of the Caledonian and Highland Railway Companies. He was a J.P. of Perthshire and Lanarkshire. Throughout his business life Mr. Stewart took a lively interest in the welfare of his workers, and by the provision of institutes and recreation rooms endeavoured to improve their lives and conditions.

Company News.

Thanet Electric Factors, Limited.—Capital £500 in £1 shares.

Bergmann Electric Company, Limited.—Capital £5,000 in £1 shares.

Projectile and Engineering Company, Limited.—Dividend, 5 per cent. for 1924.

Forrest Coal Company, Limited, County Buildings, Airdrie.—Capital £2,000 in £1 shares.

Associated Equipment Company, Limited.—Profit, £48,364; brought forward, £4,733; carried forward, £53,097.

Coneygre Foundry, Limited, Coneygre Road, Tipton, Staffs.—Capital £12,000 in £1 shares (4,500 10 per cent. preference).

Robinson's Engineering Company, Limited, Heaton Works, Strand-on-the-Green, Chiswick, London, W.4.—Capital £5,000 in £1 shares.

United Alkali Company, Limited.—Final dividend, 7½ per cent., less tax, making 12½ per cent. for year; carried forward, about £100,000.

Eastern Hemisphere Whaley Engine Company, Limited.—Capital £1,000 in £1 shares. Solicitors: Pinsent & Company, Birmingham.

British Metal Corporation, Limited.—Reserve, £50,000; net profit, £81,687; dividend, 8 per cent., less tax, £78,480; carry forward, £18,265.

Northern Metalcrafts, Limited, 15, Stoddart Street, Newcastle-on-Tyne.—Capital £2,000 in £1 shares. Directors: W. E. Nuttall and M. Hudson.

The Glamorgan Tinplate Company, Limited.—Capital £200,000 in £1 shares. Solicitors: Waltons & Company, 101, Leadenhall Street, London, E.C.

John Busfield, Limited, Lloyds Bank Chambers, 28 and 29, Grand Parade, St. Leonards-on-Sea.—Capital £2,000 in £1 shares. Engineers. Director: J. Busfield.

Alcock & Bamber (Blackpool), Limited, 6, Gorton Street, Blackpool.—Capital £2,500 in £1 shares. Motor, electrical and general engineers, etc. Director: E. Alcock.

Magnetic Separators, Limited, 561B, Silvester Street, Liverpool.—Capital £500 in £1 shares. Directors: W. S. H. Bevin, R. Greaves, F. G. Bevin and J. S. Rawsthorne.

Moray Engineering Company (London), Limited, Lutheran Place, Upper Tulse Hill, London, S.W.2.—Capital £600 in £1 shares. Directors: H. Coles and H. J. Carter.

Davidson & Edgar, Limited, 63, Castle Street, Edinburgh.—Capital £3,000 in £1 shares. Engineers. Directors: W. Hunter, A. J. Davidson, E. L. Gray and W. Edgar.

Lilleker Brothers, Limited.—Capital £3,000 in £1 shares. Electrical engineers. Directors: A Lilleker, Danum House, Bradgate Lane, Rotherham; J. Lilleker and W. Lilleker.

J. B. Hindley, Limited, 9 and 11, Waingate, Sheffield.—Capital £1,500 in £1 shares. Tool merchant. Directors: J. B. Hindley and J. B. Hindley, jun. (assistant manager).

Towler & Son, Limited, 85-87, High Street, Stratford, E.15.—Capital £10,000 in £1 shares. Boiler makers. Directors: W. T. Towler, Marion E. Towler and W. T. Towler, jun.

Fairburn & Hall, Limited, Injection Works, Blue Shop Yard, Daw Bank, Stockport.—Capital £1,000 in £1 shares. Ironfounders. Directors: S. O. Flint, D. Riley and J. Blackburn.

Weightless Beam Company, Limited, Moorbrook Mill, Preston.—Capital £500 in £1 shares. Engineers, founders, etc. Directors: C. F. Crutchley (chairman), A. Crutchley and J. Aspin.

Manvers, Limited, Bank Chambers, 329, High Holborn, London, W.C.1.—Capital £2,000 in £1 shares (1,000 7½ per cent. cumulative preference and 1,000 ordinary). Machinery manufacturers.

British Oxides, Limited.—Capital £1,000 in £1 shares. Zinc oxide manufacturers, etc. Directors: W. Holmes, J. P. Williams and A. Williams. Secretary: A. F. Carrol, 19, Duffield Road, Pendleton, Manchester.

Hugo Stinnes, Limited, 29, St Vincent Street, Glasgow.—Capital £100,000 in £1 shares. Coal masters, colliery proprietors, etc. Directors: Hugo Stinnes, junr., Mulheim, Ruhr; H. B. Williams, 29, St. Vincent Place; and E. Balster.

Electrical Distribution of Yorkshire, Limited.—Speaking at the annual meeting of the Electrical Distribution of Yorkshire, Ltd., last Tuesday week, the chairman said that the steady progress of the company, which is indicated by the report, shows the wisdom of the policy of the company to supply at the lowest possible prices consistent with steady development and sound finance. The total capital expenditure during 1924 exceeded £107,000, an amount considerably greater than that spent in 1923. This large sum has been required because of the increased area in which the company has powers to supply and to meet new connections made during the year. The development of the new districts in which the company has been authorised to supply will entail a large expenditure of capital during 1925, estimated at £189,000. The present issued capital, continued the chairman, is only £250,000, so that the company will have to have more money in due course. The directors do not, however, intend to make an immediate issue. The profits of the year would enable a larger dividend to be paid than 7 per cent., but owing to the development mentioned it is important that the reserves of the company should be fully maintained, and the board again recommend the same dividend.

Contracts Open.

Copenhagen.—Rotary converters, for the Copenhagen Lighting Department. The Department of Overseas Trade (Room 52).

Melbourne.—One 15-ton electric travelling Goliath crane, for the Victorian Government Railways. The Department of Overseas Trade.

Johannesburg, South Africa, April 20.—Structural formers, for the Municipal Council of Johannesburg. The Department of Overseas Trade (Room 52).

Hull, March 13.—Supply and erection of four high-pressure steam superheaters of British manufacture, for the Corporation. Mr. C. B. Newton, city water and gas engineer.

Southport, March 20.—Weighbridge, for the Southport, Birkdale and West Lancashire Water Board. Mr. C. B. Ede, engineer and manager, 14, Portland Street, Southport.

New York, March 16.—Cast-iron pipes, specials, valves, hydrants, etc., for the City of New York Department of Purchase. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

Johannesburg, South Africa, April 20.—Supply and delivery of structural steelwork for a bridge, for the South African Railways and Harbours. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

Institute of British Foundrymen.

SCOTTISH BRANCH: Propaganda Meeting at Paisley.

Under the auspices of the Scottish Branch of the Institute of British Foundrymen, a largely attended meeting was held in the Technical College, George Street, Paisley, when an important lecture on "Cupola Practice" was delivered by Mr. R. R. McGowan, Glasgow, who is a Past-President of the branch.

BAILIE GALT occupied the chair, and his opening remarks referred to the growth of the Institute since its inception in 1904, when it was founded under the name of the British Foundrymen's Association. He pointed out the great need for increased technical skill in the foundry, if this department of the engineering industry was not to fall behind, and suggested that in a town like Paisley, depending so largely on the ironfoundry trade, better use should be made of the educational facilities offered by the Institute.

MR. MCGOWAN, in his lecture, dealt very fully with cupola practice in all its bearings. Beginning with the design of the cupola, he pointed out the importance of having correct ratios between melting zone and tuyere areas, especially with regard to the class of work to be done. He then traced in detail the work involved in getting the cupola ready for work, and explained fully the methods of preparing the bottom, lighting and charging, and making up the breast. The chemical reactions in the cupola were afterwards fully and simply explained, and also the purpose of the bed charge. Mr. McGowan thereafter dealt with the melting capacities of different sizes of cupolas, and explained, by calculation and otherwise, the correct amount of iron, coke and flux forming a charge in each case. The concluding part of the lecture dealt with the calculations necessary to obtain a required percentage of silicon or other element when two or more brands were available, and with the methods of determining blast pressure and volume, and the importance of these on the correct working of the cupola.

A brief discussion followed, in which Mr. A. Lawrie and Mr. H. M. Hodgart took part. Both speakers emphasised the value of the Institute, and appealed for support, suggesting that an effort should be made to inaugurate a section under the jurisdiction of the Scottish Branch.

On a show of hands being asked for by the chairman, a considerable number of those present agreed to give the proposed section their support.

On the motion of Mr. Hodgart, a hearty vote of thanks was accorded Bailie Galt, as chairman, and Mr. McGowan for his lecture.

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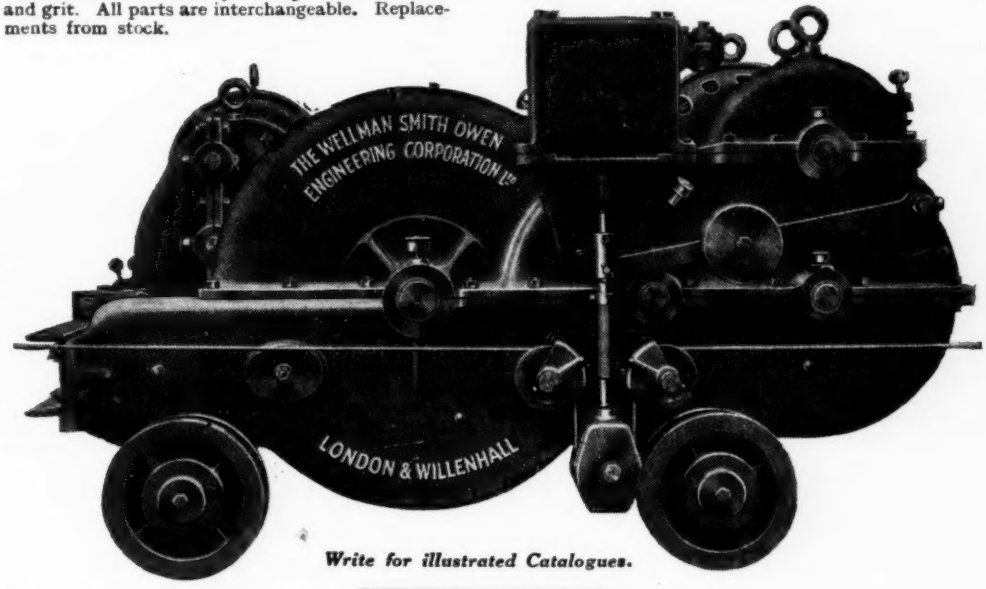

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The inactive conditions remarked of late in the Cleveland iron market continue unrelieved, and the tone throughout, both as regards home and export business, is depressed in the extreme. In normal times, when home inquiry has fallen off, there has usually been found some compensation in a spurt of export buying, but on this occasion shipments for the month just closed amount to a total only of 27,733 tons, as compared with 31,186 tons in January, a decrease of 3,453 tons. The figures serve to illustrate the quiet times which the Tees-side industry is experiencing, and will also account for the pessimistic feeling expressed in market circles. In the circumstances outlined it is not surprising to find a weaker tendency in values, although nominally prices are unchanged, as follow:—No. 3 G.M.B., 78s. per ton; No. 1, 83s.; No. 4 foundry, 77s.; and No. 4 forge, 76s. per ton.

In the hematite section, the home demand is still far below normal, and with the export trade very restricted, smelters are being compelled to put a good deal of iron into stock. Last week the prices of East Coast mixed numbers suffered a further cut of 6d. per ton, bringing the quotation down to 85s. per ton, as compared with 88s. at the beginning of the year. No. 1 is now 85s. 6d. per ton. On the West Coast, with business chiefly of a hand-to-mouth character, prices are also somewhat easier, and Bessemer mixed numbers are quoted at 92s. 6d. per ton, c.i.f. Welsh ports, 95s. per ton delivered at Glasgow, 100s. per ton delivered at Sheffield, and 102s. 6d. per ton delivered at Birmingham.

LANCASHIRE.—The demand for foundry iron in the local markets continues on a minimum scale, with sellers of Derbyshire No. 3 pig quoting 87s. 6d. per ton for delivery in Manchester. Lincolnshire pig is a little dearer, owing to scarcity, and Northamptonshire fractionally cheaper. Scotch foundry iron is quoted at round 106s. 6d. per ton delivered Lancashire, but it is understood that lower prices are being taken. The actual quantity of Scotch now required for the local foundry trade is only small, and the price prevents its use.

THE MIDLANDS.—The local markets for foundry iron are again without special features of interest, with buying entirely restricted to the barest immediate requirements, and values a shade weaker. Quotations rule as follow:—Derbyshire No. 3 foundry, 79s. to 80s.; Staffordshire No. 3 foundry, 80s. to 82s. 6d.; Northants No. 3 foundry, 73s. to 74s. 6d.

SCOTLAND.—Only a small volume of business is passing in this area, with No. 3 foundry pig at furnaces quoted nominally at 89s. per ton. Continental iron is coming forward in fairly large tonnage, but the price of foundry is now so near that of home iron that there is not much benefit in buying abroad. Continental foundry is quoted to-day at 81s. f.o.t. Grangemouth.

Finished Iron.

Only moderate activity can be reported in this section of the industry, as applies to makers of marked bars, while other qualities remain in sluggish demand, especially for crown and nut and bolt iron. Values, however, are not altered in any way, and £12 10s. to £12 15s. for crown and £11 15s. for bolt iron are the current quotations. The demand is quite inadequate to keep up anything like regularity of working operations, and the competition for any orders there are moving is very keen. The shipments of manufactured iron and steel from Middlesbrough during January amounted to 54,397 tons, as compared with 52,749 tons in February, an increase of 1,648 tons. The coastwise shipments at 17,703 tons were down by 176 tons, but the shipments abroad at 36,694 tons were better by 1,824 tons.

Steel.

In the Sheffield steel market business in basic billets is very flat, but for acid billets there is a trifling improvement. Business in all classes is expected to make a better show if Belgian and French prices continue to rise, for it is the recent sharp Continental competition which has cut so heavily into home business. In the market for alloys the Continental demand for ferro-manganese is very moderate, and is not much larger than the home consumption. American business is much on the same scale, the present price of domestic and imported being £24 3s. duty paid and tidewater. The tinplate market continues to be quiet, and the volume of business done has not been satisfactory. The recent reduction in the basis price to 22s. 1½d. per standad box has, no doubt, caused consumers to adopt caution for the time being.

Scrap.

The general slackness prevailing in the foundry industry will probably explain the corresponding dulness in the various markets for scrap material, which at the moment are exceptionally quiet. In Lancashire, it is said, there is a surplus of cast scrap on the market, and as a consequence there are weak sellers about who tend to bring prices down. The usual range of prices is from 80s. to 87s. 6d. per ton, delivered Manchester, the higher price being for scrap from textile machinery. Probably a fair quality of cast scrap could be bought at less than 80s. In Scotland there is practically no change in machinery cast-iron scrap, and odd lots are being done around 86s. to 86s. 6d. per ton, and for ordinary quality 5s. per ton less. Cast-iron railway chairs are still quiet around 85s. Light cast-iron scrap and firebars have been done recently at 72s. 6d. per ton. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Recent movements in the standard market have been somewhat difficult to follow, the lower tendency of values being hardly justified by the actual position of the metal. Consequently sellers have become more reserved, the much larger inquiry for all positions to May having strengthened their hands. This inquiry was bound to come out, as underlying factors do not appear to warrant the inactivity of the last week or so. Current quotations:—*Cash*: Thursday, £64 5s.; Friday, £64 5s.; Monday, £64 5s.; Tuesday, £63 12s. 6d.; Wednesday, £63 12s. 6d.

Three Months: Thursday, £65 7s. 6d.; Friday, £65 7s. 6d.; Monday, £65 5s.; Tuesday, £64 12s. 6d.; Wednesday, £64 12s. 6d.

Tin.—The opening days of the month were marked by a heavy fall in tin values, due to the sales in the Straits at substantially lower prices, which caused acute depression in the home market. The monthly statistics showing an increase of 654 tons proved to be rather better than was expected, but this did not stay the liquidation, and without support the market gave way. The visible supply is 1,756 tons greater than at the end of February, 1924, but is 1,566 tons less than at the corresponding period of 1923. Current quotations:—*Cash*: Thursday, £251 10s.; Friday, £248 17s. 6d.; Monday, £245 10s.; Tuesday, £242 5s.; Wednesday, £244 7s. 6d.

Three Months: Thursday, £255; Friday, £252; Monday, £249; Tuesday, £245 15s.; Wednesday, £247 17s. 6d.

Spelter.—Due to a generally limited demand, especially for the near positions, values of this metal experienced a heavy setback on March 2, but the fall was only temporary, and the market has since recovered in undertone, with a fair volume of sales now recorded. Current quotations:—*Ordinary*: Thursday, £36 7s. 6d.; Friday, £36 6s. 3d.; Monday, £36 3s. 9d.; Tuesday, £35 17s. 6d.; Wednesday, £35 2s. 6d.

Lead.—The market for soft foreign pig also shared in the general depression of values early this month, but has since improved to some extent, with values now only fractionally lower than those recorded previous to the slump. Current quotations:—*Soft foreign (prompt)*: Thursday, £37 15s.; Friday, £37 15s.; Monday, £38; Tuesday, £37 5s.; Wednesday, £36 17s. 6d.

Mr. Wesley Lambert, of J. Stone & Company, Limited, Deptford, S.E., and a member of the Council of the Institute of British Foundrymen, sails on the 20th inst. in the "Arundel Castle" for South Africa.

On the occasion of his retirement after 31 years' service with C. A. Parsons & Company, Limited, Heaton, Mr. T. Currah, foreman patternmaker, has been the recipient of presentations. Mr. A. Crocker, works manager, presided.

The directors of the Bengal Iron Company, Limited, have entered into a provisional agreement with the Indian Iron and Steel Company, Limited, of Calcutta, the main object of which is to arrange for a merger of interests between the two concerns. The Indian Company own and operate a blast furnace plant at Burnpur, about 8 miles from the Bengal Company's works. The Indian Company will create an issue of first mortgage sterling debentures to the amount of £700,000, of which £550,000 will be issued.